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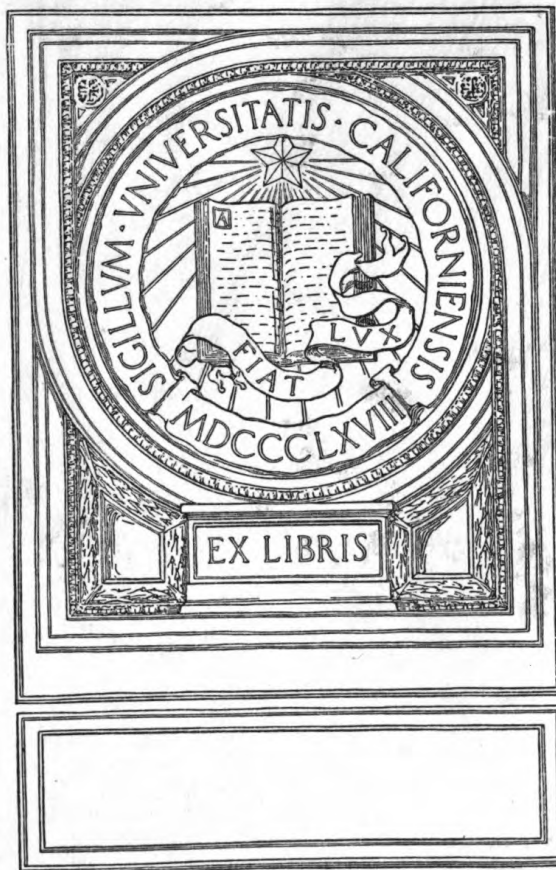
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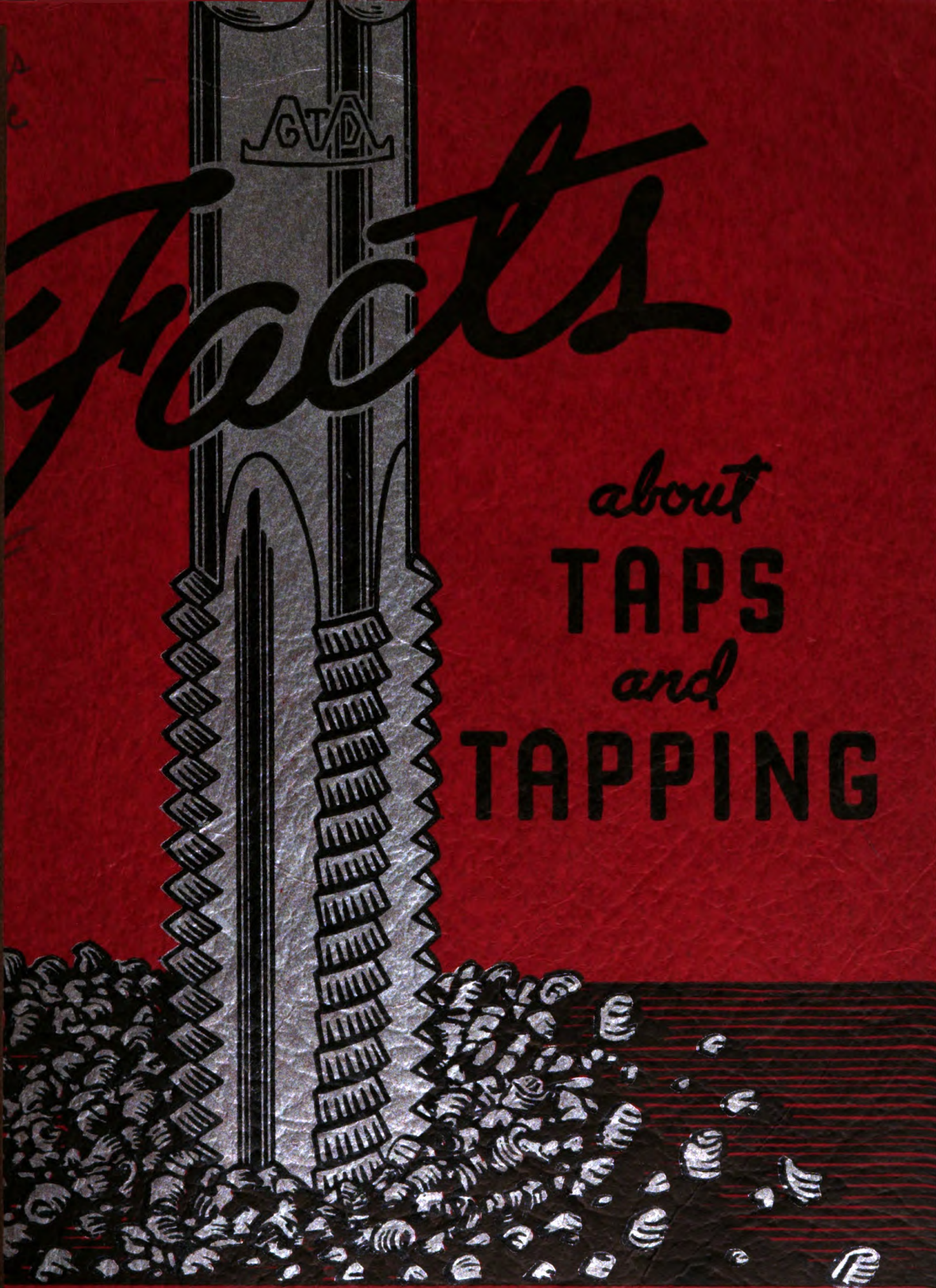
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Facts

about
TAPS
and
TAPPING



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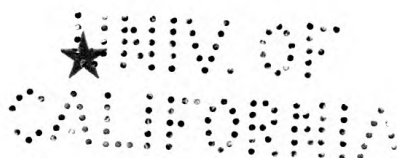
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TAPS *and* TAPPING



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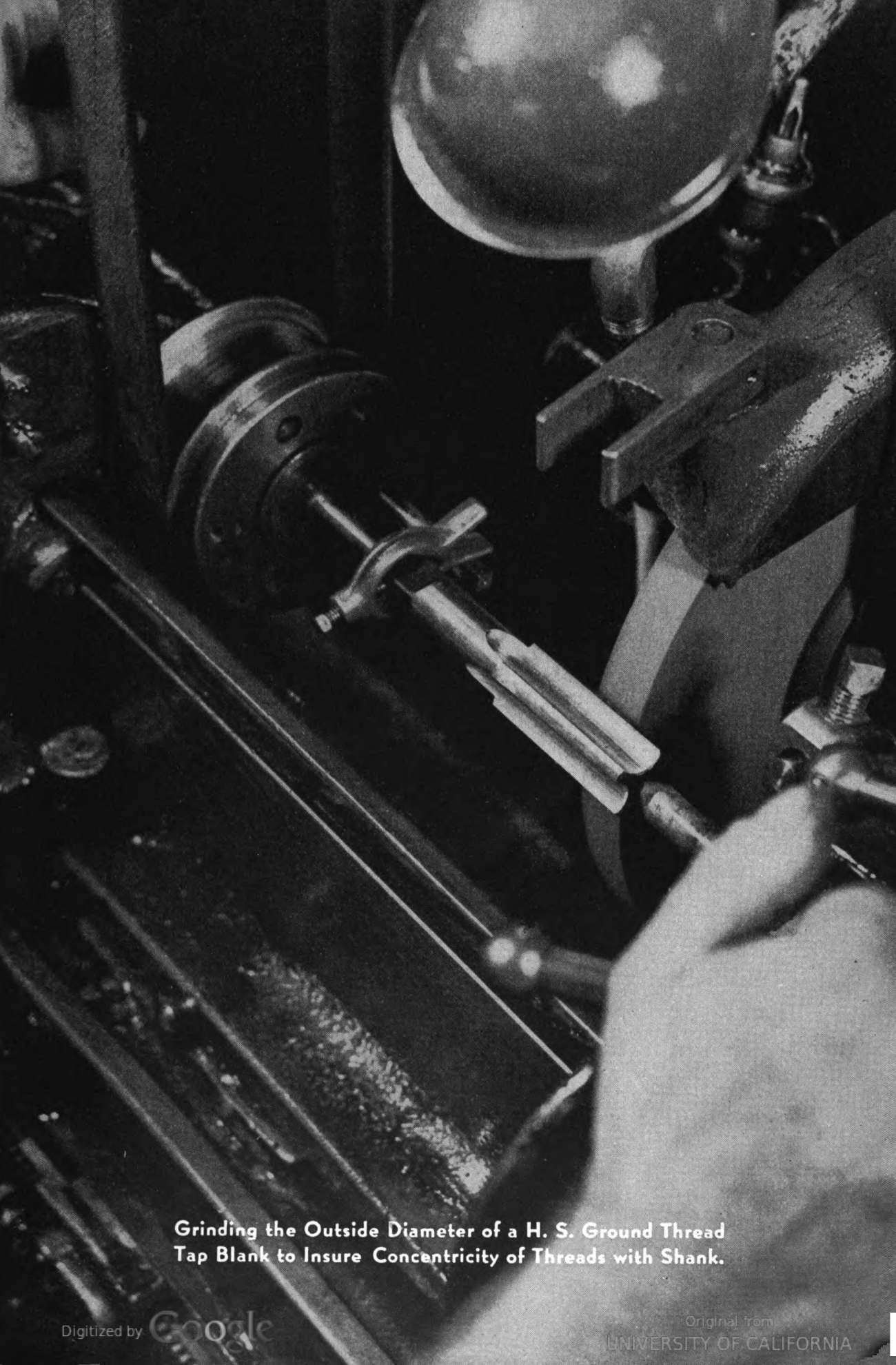
Foreword

YEARS of experience with tapping problems in thousands of plants throughout the country, and the many requests which come to us daily from shopmen, designers, students, salesmen, etc., for information about the selection and use of taps, have impressed us with the need for this handbook, "Facts about Taps and Tapping." We, therefore, present this book with the hope that it may help those interested in tapping to select the proper taps for their requirements, and to use such taps to their fullest efficiency.

Because of the many factors involved in the tapping operation, a mere description of the various types of taps, and a recital of their uses, would be of slight value to users. It is for this reason that more space is devoted in this handbook to the conditions under which taps are used than to a description of the taps themselves.

However, the problem of cutting internal threads by means of taps involves so many variables that a work of this type can be no more than an introduction to the subject of Taps and Tapping; therefore, this handbook is not intended to be the final word, but merely a *guide* to suggest a solution to the every day problems of the man who may profit by our long experience in this field.





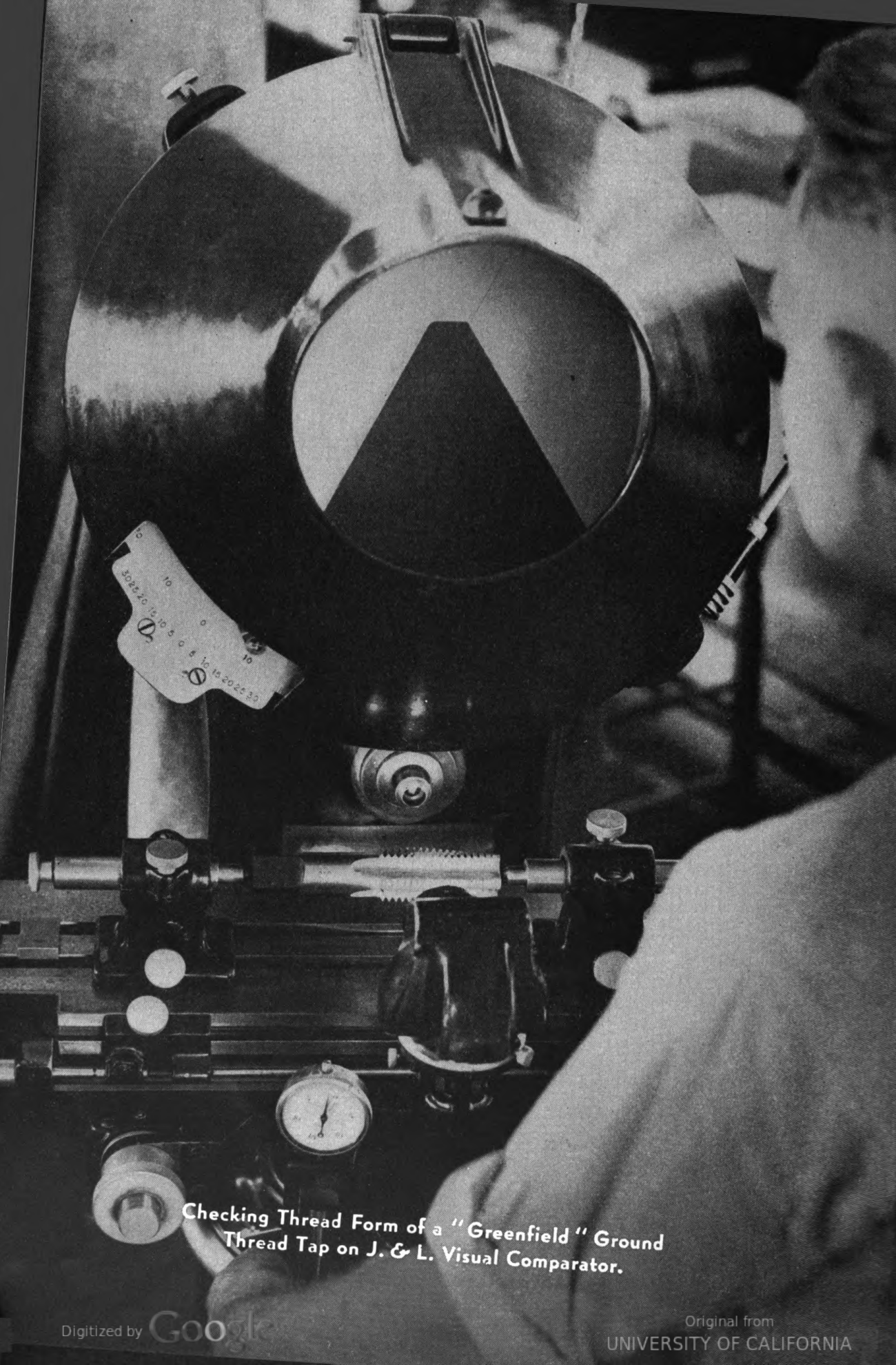
**Grinding the Outside Diameter of a H. S. Ground Thread
Tap Blank to Insure Concentricity of Threads with Shank.**



Grinding the Threads on a "Greenfield"
High Speed Ground Thread Tap.



Checking the Rake Angle on a
"Greenfield" Tap Land.



Checking Thread Form of a "Greenfield" Ground Thread Tap on J. & L. Visual Comparator.

Part I

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GLOSSARY OF SCREW THREAD TERMS AND DESCRIPTION OF TAPS AND THEIR USES . . .

ANY discussion of tapping problems presupposes a certain amount of knowledge about screw threads and the tools with which they are cut. Therefore, this section of our handbook is devoted to a presentation of the terms used in designating the elements of a screw thread, and parts of a tap, both by means of illustrations and a glossary of terms.

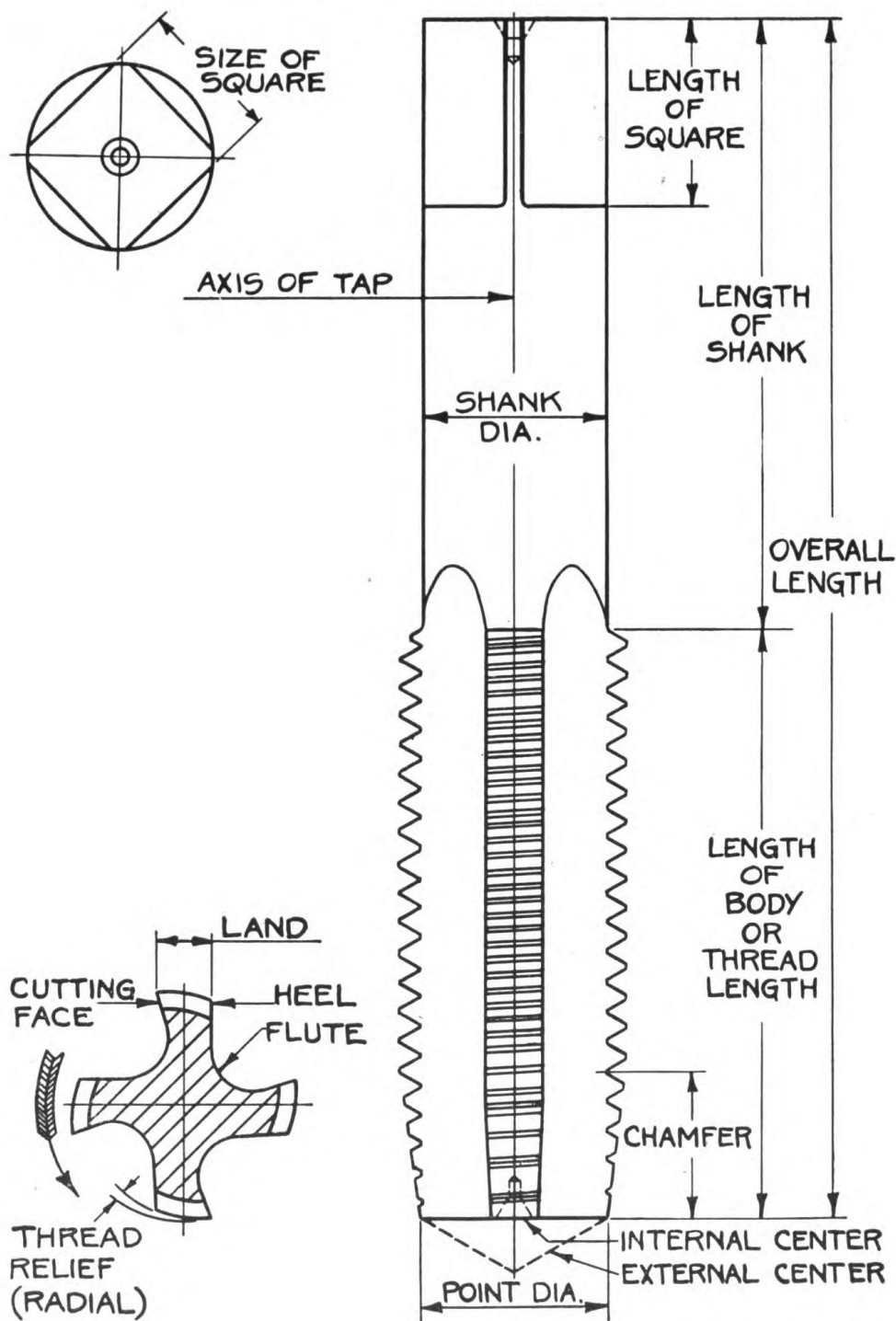
These fundamentals are followed by a description and discussion of the uses of the various types of taps commonly produced and catalogued by tap manufacturers. In addition, certain special purpose taps are considered in the light of the special conditions under which they are used and the particular details in which they differ from ordinary "regular" taps.

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Graphic Illustration of Tap Terms



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Tap and Screw Thread Terms

SO THAT the reader will readily understand and correctly interpret the various technical terms used in this handbook, we have defined below the ones most commonly used. The more important tap and screw thread terms are further explained by means of the graphic illustrations shown on the opposite page and the page following.

ANGLE OF THREAD. The angle of thread is the angle included between the sides of the thread, measured in an axial plane.

AXIS OF TAP. The longitudinal central line through the tap.

BASE OF THREAD. The bottom section of a thread; the greatest section between the two adjacent roots.

BODY. The threaded and fluted part of tap.

CHAMFER. The tapered outside diameter at the front end of the threaded section.

CREST. The top surface joining the two sides of a thread.

CUTTING FACE. The front part of the threaded section of the land.

DEPTH OF THREAD. The depth, in profile, is the distance between the top or crest and the base or root of thread measured perpendicular to the axis of the tap.

EXTERNAL (MALE) CENTER. Sometimes termed male center and is the cone shaped end of the tap. It is incorporated for manufacturing purposes and usually at the threaded end of small taps only.

FLUTE. The groove providing for the cutting faces of the threads or teeth, chip passage and lubrication.

HEEL. The back part of the threaded section of the land.

HELIX. The curve formed on any cylinder, especially a right circular cylinder, by a right line in a plane that is wrapped round the cylinder, as an ordinary screw thread.

HELIX ANGLE. The angle made by the helix of the thread at the pitch diameter with a plane perpendicular to the axis.

HOOK. The curved undercut of the cutting face of the land. (See illustration on Page 40.)

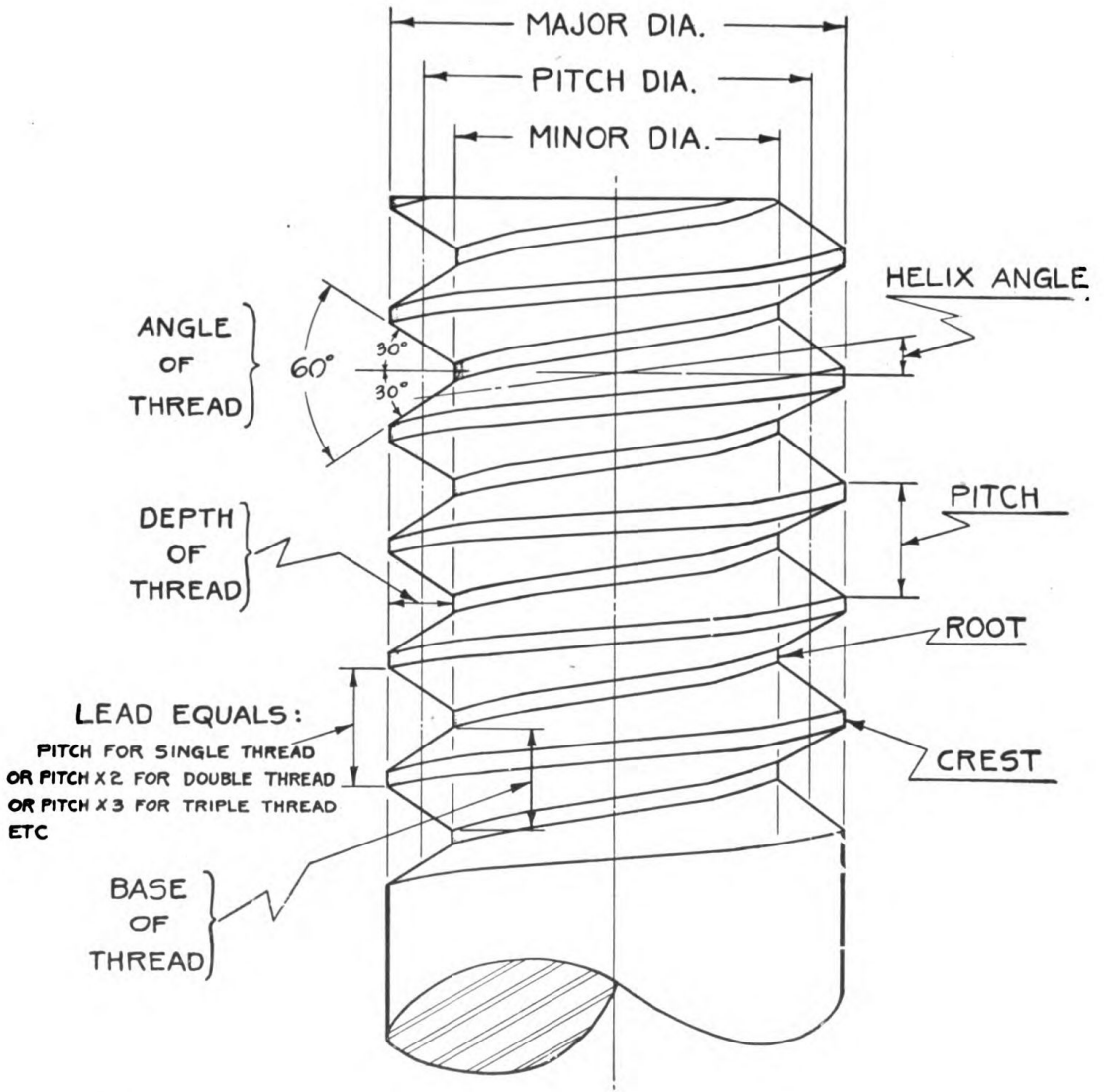
INTERNAL (FEMALE) CENTER. Sometimes termed female center and is a small drilled and countersunk hole at the end of the tap, necessary for manufacturing purposes.

LAND. The threaded web between the flutes.

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Graphic Illustration of Screw Thread Terms

AMERICAN NATIONAL FORM THREAD



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LEAD. The distance a thread advances axially in one turn. On a single thread the lead and pitch are identical; on a double thread the lead is twice the pitch, etc.

MAJOR DIAMETER. Commonly known as outside diameter. The diameter of the threaded section over the full threads measured perpendicular to the axis.

MINOR DIAMETER. Commonly known as "root diameter." The root diameter of the full threaded sections or the distance between the two opposite roots measured perpendicular to the axis.

NUMBER OF THREADS. The number of threads or teeth in one inch of length.

PITCH. The distance from a point on a thread to a corresponding point on the next thread measured parallel to the axis. The pitch expressed in a decimal dimension equals one divided by the number of threads per inch.

PITCH DIAMETER. On the full threaded sections the pitch diameter is the diameter of an imaginary cylinder which would pass through the threads at such points as to make the width of thread and the width of the spaces between the threads at these points equal.

POINT DIAMETER. The outside diameter at the front end of the chamfered portion.

RADIAL. The straight cutting face of a land which, if continued, would pass through the center of the tap. (See illustration on Page 40.)

RAKE. The angle of the cutting face of the land in relation to a straight line from the point of the cutting face to the axis. (Illustration on Page 40.)

ROOT. The bottom surface joining the sides of two adjacent threads.

SHANK. The part behind threaded and fluted section of tap.

SIDE OF THREAD. The surface of the thread which connects crest with root.

SQUARE. The squared end of the tap shank.

THREAD. The cutting tooth of the tap which produces the thread in a tapped hole.

THREAD RELIEF (RADIAL). A clearance providing a gradual decline in the major, pitch and minor diameters of the lands, back of the cutting face. This style of relief is applied only to certain sizes and types of taps.

SURFACE FEET PER MINUTE (S.F.P.M.). The distance that a rotating tap travels at a given number of revolutions per minute. This is determined by multiplying the Major Diameter of the tap by 3.1416, then multiplying the result by the number of revolutions the tap revolves in a minute and then dividing by 12.

Or when expressed in a formula:

$$\frac{\text{Major Diameter} \times 3.1416 \times \text{RPM}}{12}$$



Screw Thread Designations

RECOGNIZING the need for a standard system of screw thread designation, we have adopted the "National Screw Thread Series," recommended by the National Screw Thread Commission, as follows:

N.C., indicating American National Coarse Thread Series.

N.F., indicating American National Fine Thread Series.

N., indicating American National 8, 12 and 16 pitch Series.

N.S., indicating American National Special Thread Series.

N.H., indicating American National Hose Coupling Threads.

N.P.T., indicating American National Taper Pipe Threads.

N.P.S., indicating American National Straight Pipe Threads.

GREASE, indicating a standardized undersize straight pipe thread for grease cup fittings.

STEAM, indicating a straight pipe thread used on coupling taps.

CONDUIT, indicating an oversize straight pipe thread used on coupling taps.

V., indicating a 60 degree V thread usually with both the crest and root flattened several thousandths from the theoretical to the user's specifications.

ACME, indicating a standardized 29 degree thread.

S.B., indicating manufacturers' stove bolt standard thread.

These new designations, which supersede the old designations USS, USF, SAE, ASME, Briggs Standard Taper and Briggs Standard Straight, have been generally adopted by American tap and die manufacturers and by the mechanical world.

Thread Forms

THE following paragraphs contain brief descriptions of the principal thread forms used in the United States and foreign countries. As "Greenfield" products are sold in every civilized country in the world, naturally we are called upon to manufacture taps with so-called "foreign" thread forms such as Whitworth, Metric, British Association, Loewenherz, etc., as well as the American National, and other thread forms used in this country.

AMERICAN NATIONAL FORM OF THREAD. Adopted years ago by the National Screw Thread Commission, this thread form, formerly known as the "United States Standard" is one of the most widely used thread forms in the world. There are two standard series in commercial use, the N.C. (National Coarse) and N.F. (National Fine). Table No. 351 on Page 102 shows a diagram and gives complete specifications of this thread form.

MODIFIED V FORM. A practical modification of the Sharp "V" Form, used occasionally for special requirements. The included angle between the thread walls is 60° and the crest and root are slightly flattened although there is no standard for the width of the flats. The formula for calculating the thread depth follows:

$$\text{depth} = \text{pitch} \times .750''$$

"GREENFIELD" TOOLS

METRIC THREAD FORM. This thread form is the same as the American National thread form. It is generally designated in two standards, the International Standard and the French Standard, and is used mostly in foreign countries, particularly on the European continent. In this country it is used principally on spark plugs. Diagram and specifications of this thread form, are shown in Table No. 355 on Pages 110-11.

WHITWORTH THREAD FORM. This form of thread is used almost exclusively in Great Britain. It is also used extensively in the British Dominions, in Asia and in South America. There are two standard series commonly used, the Whitworth Standard which is a coarse thread series and corresponds to our N.C. and the British Standard Fine, a fine thread series corresponding to our N.F. Diagram and specifications are given in Table 353 on Pages 107-8.

BRITISH ASSOCIATION STANDARD THREAD FORM. The features of this thread form are similar to those of the Whitworth Thread Form except that the angle between the walls of the threads is 47 degrees 30 minutes, and the radius at the top and bottom of the thread is proportionately larger, the depth of the thread being smaller in relation to the pitch than in the Whitworth Standard thread. This thread is the standard used in the manufacture of small machine screws in Great Britain, and, to some extent, in other countries in Europe. Table 354 on Page 109 shows a diagram and specifications.

LOEWENHERZ THREAD FORM. The Loewenherz thread form was used exclusively in the past in Germany by opticians; watch and instrument makers. This thread has an included angle of $53^{\circ} 8'$ and the thread depth is $\frac{3}{4} \times$ pitch, whereas the crest and root have flats of equal width. The use of this style of thread has diminished in recent years, however, having been superseded by the 60° metric thread. In this country Loewenherz thread is used principally in the manufacture of magnetos.

ACME THREAD FORM. This thread form, adopted as standard by the National Screw Thread Commission, was designed to replace the square thread and modifications of it. Originally, this type of thread was used chiefly for producing traversing and longitudinal motions on machine tools, adjustments, etc. Now it is used extensively for a variety of other purposes. See Table 356 on Pages 112-13 for diagram and specifications.

AMERICAN STANDARD PIPE THREAD FORM. This thread form, adopted by the National Screw Thread Commission, is used principally in pipe fittings. Details are given in Table 357, Pages 114-15.

BRITISH STANDARD PIPE THREAD FORM. This form of thread is used in Great Britain and Dominions, and corresponds to our American Standard Pipe thread. See Table 358, Page 116 for specifications.

SQUARE THREAD FORM. While the use of the square thread has diminished considerably in recent years and particularly so since the advent of the Acme Thread, it is still used occasionally. The sides or walls of the square thread are parallel and the depth of the thread is equal to the width of the space between the teeth; theoretically, this space is equal to one half of the pitch.

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Development and General Application of Hand Taps

MANY different types of taps have been developed since the early "Seventies" when "Greenfield" began making these tools. While the demand for some types has lessened, and certain other types have become obsolete, the "Hand Tap" is as much in demand today as ever. Since its conception, many new problems have arisen necessitating changes in tap design, and today there are many different styles of Hand Taps; consequently, the term "Hand Tap" has a rather broad application. As several different kinds of taps come under the "Hand Tap" classification, and there is very little information in most manufacturers' catalogs pertaining to the selection and application of taps, for the enlightenment of the students of tapping, we are explaining briefly, on this and several pages following, the difference between the various kinds of Hand Taps and the types of jobs for which they are generally recommended.

The dimensions and tolerances to which Hand Taps are made have been standardized, and tables giving standard specifications are included in most manufacturers' catalogs. While the majority of tool designers use standard sizes recommended by the tap manufacturers, permitting the use of standard stock taps, some designers frequently do not follow manufacturers' standards, and, as a result, special taps have to be purchased. We, therefore, recommend that tool designers familiarize themselves with manufacturers' standards, shown in the tables in the back of this book, for expensive errors can be avoided, and tool costs lowered, by adopting standard sizes when new machines are designed.

Taper, Plug and Bottoming Hand Taps

THE most widely used tap for production tapping today is the Plug Hand Tap, although originally "Hand Taps" as the name implies, were intended for hand use. As a rule, such taps are furnished in sets of three of a size, i.e., Taper, Plug and Bottoming, when intended for hand tapping.



Taper Hand Tap



Plug Hand Tap



Bottoming Hand Tap

Taper, Plug and Bottoming, are identical as to size, length and vital measurements, their only difference being in the chamfered threaded portion at the point. The Taper Hand Tap has the longest chamfer of the three, usually about ten threads. The Plug Tap usually has about five threads chamfer, and the Bottoming Tap, one thread chamfer only.

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When tapping by hand in open or through holes, the Taper Hand Tap should be used for coarse pitch threads as it insures straighter starting. It is also recommended for the harder metals. The Plug Hand Tap can also be used in such holes when tapping soft metals or fine pitch threads. In the case of closed or blind holes when tapped by hand and down to the very bottom, all three taps, i.e., Taper, Plug and Bottoming should be used, and in the order named.

Many other types of taps described in the following pages, such as: Pipe, Pulley, Machine Screw, etc., are occasionally used by hand, but when the name "Hand Tap" is used it has reference to the type described in the preceding paragraphs.

Serial Hand Taps

THESE taps are recommended and used for tapping deep holes, open or blind, by hand, especially in tough metals, for they cut much easier and produce smoother threads than ordinary hand taps. Serial Hand Taps are similar in general dimensions to Taper, Plug and Bottoming Hand Taps, but differ from the latter in that each tap cuts only a certain percentage of the thread to be produced. Usually there are three taps to a set, numbered respectively 1, 2 and 3.



No. 1



No. 2



No. 3

The No. 1 tap, smallest of the three, both in outside and pitch diameter, makes the roughing cut. This is followed by No. 2 tap which cuts the thread a little fuller. Finally, No. 3 tap produces the finishing cut. This cutting procedure is illustrated by the sectional drawing below:



▨ = NO. 1 TAP □ = NO. 2 TAP ■ = NO. 3 TAP

Section showing Approximate Amount of Material removed by each Serial Tap

Dividing the working strain among the three taps greatly lessens the possibility of tap breakage, and simplifies the hand tapping of many difficult jobs.

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Machine Screw Taps

THESE are really small size hand taps, except that they are designated by Nos. 0 to 30, instead of fractional sizes. Each number represents a certain decimal size for which screws of corresponding diameter are made. The No. 0 size, equivalent to the decimal .060", is the smallest in the range. From this size all successive numbers are increased by increments of .013 per size. Thus, the decimal equivalent of the No. 1 size is .073", No. 2, .086", No. 3, .099", No. 4, .112" and so on.



Regular Machine Screw Tap

Very few screws beyond No. 14 are used today, as the larger sizes have been superseded by fractional sizes. For this reason, Machine Screw Taps are furnished, at regular prices, only in sizes up to and including No. 14. The use of the latter size also seems to be diminishing because it is so close to the next fractional size, which is $\frac{1}{4}$ ". The decimal equivalent of a No. 14 Machine Screw size is .242", and of the $\frac{1}{4}$ inch size, .250".

Engineers and designers should, wherever possible, specify Machine Screw sizes for tapped holes below $\frac{1}{4}$ inch because screws in Machine Screw sizes can be obtained more readily than fractional size screws in the range below $\frac{1}{4}$ inch.

When tapping thin parts or shallow holes such as are found in radio parts, lamp sockets, thin sheet metal parts and the like, "Stub" Machine Screw Hand or "Gun" Taps should be used.



Stub Machine Screw Hand Tap



Stub Machine Screw "Gun" Tap

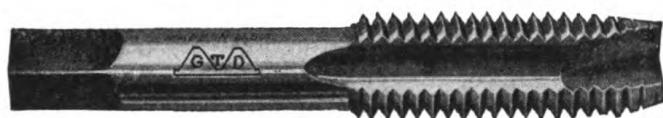
Usually such jobs are handled in automatic tapping machines which are run at very high speeds; consequently greater tap rigidity than "Regular" Machine Screw Taps provide is necessary. For this reason, "Stub" Machine Screw Taps, sizes 3 to 12, inclusive, are made in shorter lengths than "Regular" Machine Screw Taps — the shorter length being attained by a shorter threaded portion. Furthermore, "Stub" Taps have tapered flutes which provide for a gradual increase of the flute core diameter towards the shank. Obviously, this increased diameter produces a stronger flute core, which is very desirable for the type of tapping operations mentioned. Also, to provide for maximum chip room in the flutes, all sizes of "Stub" Machine Screw Hand Taps have three flutes. "Stub" Machine Screw Gun Taps have two flutes.

"Stub" Machine Screw Taps are also used extensively, and are recommended for such use, in electric hand drills and tappers.

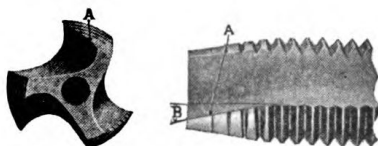
★ **"GREENFIELD" TOOLS** ★

Gun Taps

THE "GUN" TAP, introduced by "Greenfield" in 1915, has proven to be a major tap development. As to general physical dimensions, this style of tap is identical with the Plug Hand Tap, except that the "Gun" Tap is strictly a production tool and is not intended for hand use.

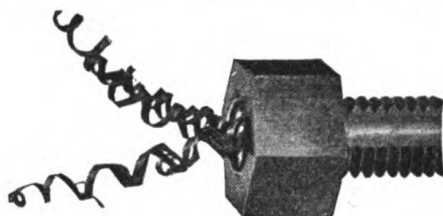


"Gun" Tap



End View — Showing spiral point

The flutes are divided into two sections — the conventional straight flute and the angular section at the point, called "Gun" flute (see cut above) having the cutting face "A" ground to a predetermined angle "B", relative to the axis of the tap. This causes the tap to cut with a shearing motion, i.e., with the least amount of resistance to the thrust. The angle "B" deflects the chips so that they curl out and ahead of the tap — "shoot ahead." Consequently, the chips do not collect and break up in the flutes. The cut below illustrates this action.



Chips "Shooting Out" ahead of "Gun" Tap in through hole

This is a very desirable feature when tapping stringy metals, for it eliminates the possibility of loading in the flutes which frequently causes tap breakage. Furthermore, when backing out or reversing the tap, the danger of damage to the threads in the tapped part by chips in the flutes is eliminated, for there is no chip accumulation in the flutes of "Gun" Taps.

The "Gun" Tap has fewer flutes than most ordinary Hand Taps of the conventional type. As the flutes in the "Gun" Tap are not required for chip passage, they are made very shallow. These are desirable features for they give the "Gun" Tap a large cross-sectional area which means greater strength. Due to this type of design, the "Gun" Tap can be run at higher speeds, requires less power to drive, and, for some classes of work, is much more economical to use than the ordinary Hand Tap.

We do not recommend the use of "Gun" Taps in blind or closed holes unless there is sufficient untapped space at the bottom of the holes to accommodate chips.

★ "GREENFIELD" TOOLS ★

Two and Three Fluted Hand Taps

STANDARD HAND TAPS $\frac{1}{16}$ " to $\frac{1}{8}$ " inclusive, and Machine Screw Taps, Nos. 0 to 6, inclusive, unless otherwise specified, are furnished with three flutes, whereas fractional sizes $\frac{5}{32}$ " to $\frac{1}{2}$ " inclusive, and Machine Screw Sizes No. 8 and larger are furnished with four flutes. For the general run of tapping operations, these standard taps have sufficient flute space to permit chip passage. However, there are certain types of tapping jobs, such as tapping soft and stringy metals, deep holes tapped horizontally in screw machines or deep blind holes tapped vertically, which necessitate the use of taps with greater flute space.

Chip room is an important factor in taps for jobs of this nature, for the chips usually remain in the flutes of the tap during the tapping operation. To meet such conditions, Two and Three Fluted Hand and Machine Screw Taps were developed. Having fewer flutes than ordinary Hand and Machine Screw Taps, these taps provide more space for the passage of chips; consequently, they should be used on the types of jobs mentioned.



Two Fluted Hand Tap



Three Fluted Hand Tap

There are certain sizes of Hand Taps in the range of $\frac{1}{4}$ " and $\frac{5}{16}$ " inclusive, and Machine Screw Taps, Nos. 8 to 12 inclusive, which are regularly furnished with either two or three flutes (four flutes is standard) so, in selecting a Two or Three Fluted Tap, the question frequently arises as to which of the two types should be used. An off-hand decision as to which of the two would be better should not be made, for the selection of the proper tap depends entirely on the conditions under which the tap is to be used. We suggest the Three Fluted Tap be tried first, for, due to its construction, it is much stronger than the Two Fluted Tap. The Two Fluted Tap, having wider flutes, has less total land width and therefore does not give as much support in tapping as the Three Fluted Tap. It is also more difficult to maintain the size of tapped holes with Two Fluted Hand and Machine Screw Taps than with taps having three flutes.

Two Fluted Hand and Machine Screw Taps should not be confused with Two Fluted "Gun" Taps because the latter, which have wide lands and heavy flute core, and provide great strength and accuracy, are, as explained on the preceding page, intended for a different class of work.

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Stove Bolt Taps

STOVE BOLT TAPS are used principally for tapping nuts for stove bolts which are used to hold together stove parts. Sizes of stove bolts range from $\frac{1}{8}$ " to $\frac{1}{2}$ ", inclusive. At present, there are in use, two standards, one, an old specification called the "Manufacturers' Standard" and the other a comparatively new specification called the "American Standard." The latter conforms to the Federal and American Standards Association specifications.



Both of the above mentioned standards are commonly used, but the new "American Standard" permits the use of standard stock Machine Screw and Hand Taps in both carbon and high speed steel, whereas in the old "Manufacturers' Standard," sizes $\frac{3}{16}$ -24, $\frac{1}{4}$ -18 and $\frac{5}{16}$ -18 are regularly furnished in carbon steel only — all other carbon and all high speed sizes are special.

The following table lists tap sizes for both standards:

Manufacturers' Standard (Old)			American Standard (New)	
Stove Bolt & Tap Size	Carbon Taps	High Speed Taps	Stove Bolt Size	Tap Size
$\frac{1}{8}$ -32	Special	Special	$\frac{1}{8}$ -40	Regular
$\frac{5}{32}$ -28	Special	Special	$\frac{5}{32}$ -32	in both
$\frac{3}{16}$ -24	Regular	Special	$\frac{3}{16}$ -24	carbon
$\frac{7}{32}$ -22	Special	Special	$\frac{7}{32}$ -24	and
$\frac{1}{4}$ -18	Regular	Special	$\frac{1}{4}$ -20	high-
$\frac{5}{16}$ -18	Regular	Special	$\frac{5}{16}$ -18	speed
$\frac{3}{8}$ -16	Special	Special	$\frac{3}{8}$ -16	steel
$\frac{1}{2}$ -14	Special	Special	$\frac{1}{2}$ -13	
				5-40 Mach. Screw
				8-32 Mach. Screw
				10-24 Mach. Screw
				12-24 Mach. Screw
				$\frac{1}{4}$ -20 Hand
				$\frac{5}{16}$ -18 Hand
				$\frac{3}{8}$ -16 Hand
				$\frac{1}{2}$ -13 Hand

Stove Bolt Taps made to the old "Manufacturers' Standard" have the same physical dimensions as Plug Hand Taps, except that they have a slightly larger pitch diameter than Hand Taps of similar size and pitch. On the other hand, the new "American Standard" calls for the use of regular Machine Screw and Plug Hand Tap sizes. For this reason, the buyer of Stove Bolt Taps should state, when ordering, whether he wants taps to produce the old "Manufacturers' Standard" or the new "American Standard."

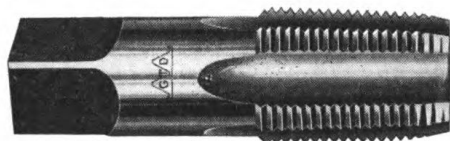
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Miscellaneous Standard Taps

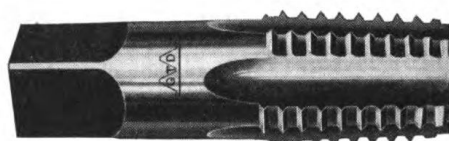
IN ADDITION to the Hand Taps previously described, there are also available numerous other types. While the function of these taps is fairly well understood by users, a brief discussion of each type will no doubt be of interest to executives, buyers, engineers, and others responsible for proper tap procurement.

Taper Pipe Taps

TAPER PIPE TAPS are used ordinarily for tapping pipe fittings, although they also have numerous other applications. In producing pipe fittings, extremely tight fits are necessary, so, to accomplish this, the threaded portion is tapered. The diameter of the tap increases from bottom to top of threaded portion at the rate of $\frac{3}{4}$ inch per foot, whereas, the angle formed by the sides of the thread is 60° when measured in an axial plane, and a line bisecting this angle is perpendicular to the axis of the tap. These thread specifications are in accordance with the standard approved by the National Screw Thread Commission.



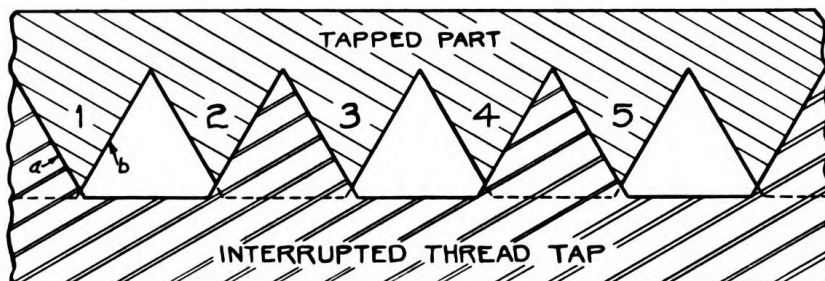
"Regular" Taper Pipe Tap



Interrupted Thread Taper Pipe Tap

Taper Pipe Taps are also made with interrupted threads, i.e., every other tooth in successive lands is removed.

The drawing below illustrates the cutting action of an interrupted thread tap and shows that only one side of any of the threads 1, 2, 3, 4, or 5 of the nut is in contact with a tap tooth. This allows the full strength of each thread to resist the cutting strains presented from one side only. Thus side "a" of thread "1" is being formed by the tap tooth while side "b" is free. Hence the entire thread section "1" is available to resist the strain and pressure of this cut.

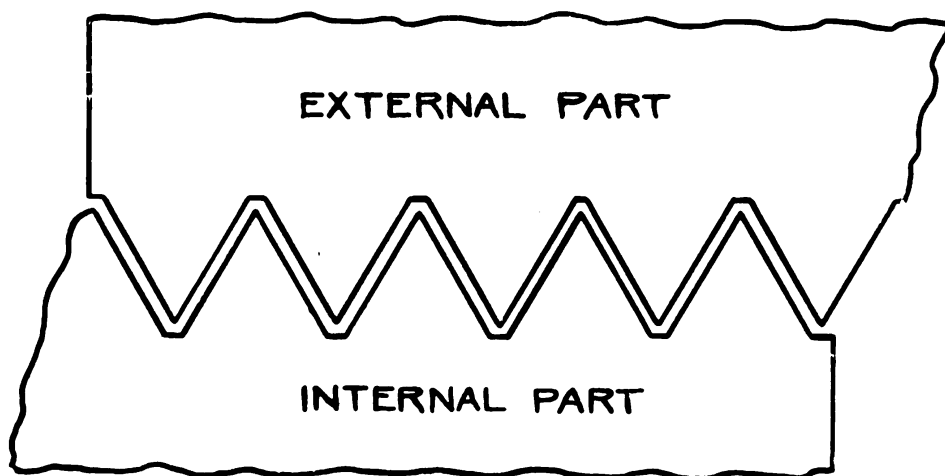


Interrupted Thread Tap

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With regular taps the thread strength is the same but the tap cuts on both sides "a" and "b" of every thread. This added strain is sometimes excessive, frequently causing metal from the crest to adhere to the root of the tap, producing a torn thread and a loaded tap, when tapping soft, stringy material. The removal of alternate teeth also provides a groove, permitting the escape of chips and the thorough lubrication of the material just ahead of the cutting teeth.

The interrupted type of thread on a Taper Pipe Tap produces a sharper crest in the minor diameter of the tapped part, which is very desirable when pressure tight fits are required.



Thus, in assembly, the sharp crests contact the flat roots just before the thread flanks match and when the make-up is completed, these sharp crests are swedged into the flats completely sealing the helix, which formerly caused leaky joints. The above sketch illustrates this point more clearly.

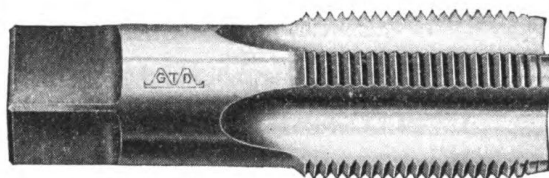
In order to produce this thread design internally, the major diameter of the tap must be flatted and the minor diameter made as sharp as possible. The sharpness of the minor diameter is dependent upon the tools used when producing the threads, but it is impossible to produce a truly sharp minor diameter in the tap on account of tool wear or grinding wheel wear.

The interrupted thread tap can be made with a minor diameter below the theoretical sharp root and since the thread form is produced alternately by successive lands, a sharper crest can be produced in the minor thread diameter of the tapped product.

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Straight Pipe Taps

IN GENERAL DESIGN the Straight Pipe Tap is identical with the Taper style — the only difference being in thread design which is straight, the same as on Hand Taps. The pitch or number of threads per inch is also identical.

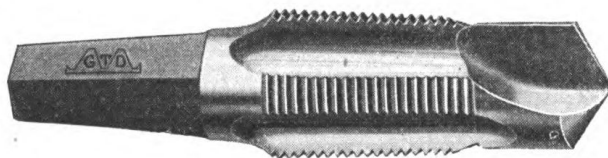


The basic pitch diameter of the straight pipe tap is the same as that of the taper pipe at the gaging notch. This is illustrated more effectively in Table 357, Pages 114 and 115.

Straight Pipe taps are used principally for tapping lock nuts and couplings for pipe connections. Some of the smaller sizes, up to 1" inclusive, are also used for tapping grease cup fittings, but the pitch diameters of the taps for the grease cup fittings are somewhat smaller than for the regular straight pipe taps, therefore, taps intended for grease cup fittings should be ordered accordingly, i.e., the order should specify "For Grease Cup Fittings."

Combined Pipe Taps and Drills

THIS type of tool, as the name implies, is a combination of a tap and drill. The drill portion preceding the tap has two flutes like a twist drill and the point is ground with the same angle as a regular drill. The tap portion is made to the same specifications as a regular taper pipe tap. The shank end is usually made with a taper square to fit a ratchet holder although there are also other shank designs which conform to the type of holders designed for specific machines.



Combined Pipe Taps and Drills are designed for drilling and tapping in one operation. Usually, the hole to be tapped is a through hole or of a design that will permit the drill to clear while the tap is engaged in the cutting of the thread. This style of tap is also well adapted for tapping cored holes, as the sizing of the hole prior to tapping requires the removal of a certain amount of material which can be taken care of very nicely with the drill section of the tap.

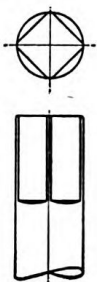
Water and Gas Companies are large users of Combined Pipe Taps and Drills to make connections in water and gas mains while under pressure. A special tapping device attached to the main permits drilling and tapping in one operation, greatly reducing the loss of water or gas and making the shutting off of the service to the consumers unnecessary during the operation.

Tapper Taps

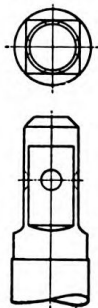
STRAIGHT SHANK. This is one of the two types, which are generally used today by nut manufacturers for production tapping. Their primary function is the same as that of Nut Taps although they differ structurally from the latter in several respects. Their overall lengths are greater, their thread lengths shorter, and they have shorter chamfered portions. Furthermore, sizes up to and including $\frac{1}{2}$ inch have three flutes, whereas Nut Taps in similar range have four flutes.



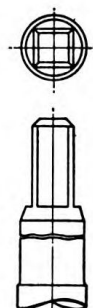
Frequently, Tapper Taps are ordered with a shank design other than *Plain Round*, the style that tap manufacturers regularly carry in stock. The various shank designs principally used are: Plain Round, Squared, Acme Improved Type "C" and National Interchangeable Ring Lock, shown below.



Plain Round or
Squared

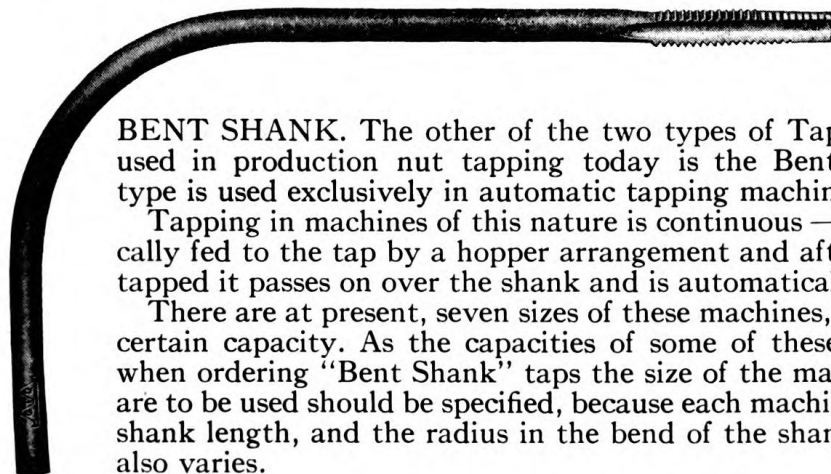


Acme Improved
Type "C"



National Interchangeable
Ring Lock

Each type of shank necessarily is used with a different type of holder so, when ordering Straight Shank Tapper Taps, the type of shank desired should be specified on the order — likewise the overall length desired when more than one overall length is listed in the tap manufacturers' catalog.



BENT SHANK. The other of the two types of Tapper Taps generally used in production nut tapping today is the Bent Shank style. This type is used exclusively in automatic tapping machines.

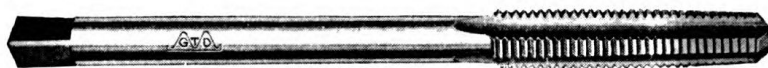
Tapping in machines of this nature is continuous — nuts are automatically fed to the tap by a hopper arrangement and after the nut has been tapped it passes on over the shank and is automatically ejected.

There are at present, seven sizes of these machines, each of which has a certain capacity. As the capacities of some of these machines overlap, when ordering "Bent Shank" taps the size of the machine in which they are to be used should be specified, because each machine requires a certain shank length, and the radius in the bend of the shank for each machine also varies.

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Nut Taps

NUT TAPS, (sometimes called Machine Nut Taps) are designed for machine use, and tapping nuts. The threaded portion has a long chamfered section which distributes the cutting over many teeth, and also facilitates the entering of the hole to be tapped. The shank is made smaller than the root or minor diameter of the threads. This permits of several nuts being gathered on the shank after being tapped. When the shank is filled, the tap is taken out of the machine and the nuts removed. This eliminates the necessity of reversing the tap after each nut is threaded.



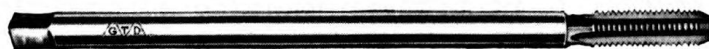
Nut Taps are used in bolt cutters (threading machines), drill presses, etc., where the nature of the work requires a tap with a long shank or where the hole is of a depth greater than can be handled by a Hand Tap.

Most production nut tapping jobs are done with Tapper Taps, which are described on the preceding pages. However, there are certain tapping jobs which can be handled to better advantage with Nut Taps, particularly the tapping of small quantities of nuts made from tough materials such as bronze, nickel steel, stainless steel and similar alloys.

The reason for this is that Nut Taps, due to their shorter overall lengths, are stronger than Tapper Taps, consequently they are more capable of absorbing the torsional strains created in the tapping of these materials. Furthermore, the longer threaded portions of Nut Taps permit of longer chamfered sections which distribute the cutting load over more teeth of the tap lands.

Pulley Taps

PULLEY TAPS derive their name from the parts which they are required to tap, namely — Pulleys. In the hub of these parts are oil cup and set screw holes, the majority of which cannot be reached with ordinary Hand Taps. Pulley Taps have the same basic thread dimensions as Hand Taps but they differ from the latter in that they have longer shanks which are of the same basic major diameters as the threaded portions. See cut below.



When tapping holes in pulley hubs, the taps are inserted through holes in the rims which are slightly larger than the shanks of the taps. These holes serve as guides for the taps and assure proper alignment and straight entrance into the holes to be tapped. Due to the varying diameters of pulleys, pulley taps are furnished in several different overall lengths; consequently, orders for these taps should specify the overall length wanted.

"GREENFIELD" TOOLS

Staybolt Taps

STAYBOLT TAPS are used principally in Boiler, Locomotive and Railroad Shops for tapping the staybolt holes in the inner and outer plates or shells of boilers. The distance between these shells varies and when both shells are tapped, the tap must be of sufficient length to tap both holes in one operation so that the threads in each hole will be in true alignment, and have the same lead.



The cutting portion of the tap as shown above is divided into three parts, namely, the threaded section, the reamer section and the pilot point. As a general rule, the holes in boiler plates are drilled smaller than required for tapping, which permits of their being reamed prior to the tapping operation. If drilled to size, it would be impossible to line up the hole in the outer plate with the mating hole of the inner plate; consequently, these holes must be drilled small to permit of their being lined up by the reaming operation, done with the reamer section of the tap. While the first hole is being reamed and tapped, the pilot point lines up with the second hole, thus assuring perfect alignment for both holes. Staybolt Taps are regularly furnished with 12 threads to the inch.

Spindle Staybolt Taps

SPINDLE STAYBOLT TAPS are used principally for repair work such as re-tapping the staybolt holes in boiler plates which are only a short distance apart. Usually this requires re-tapping to the next larger sixteenth size. To insure both tapped holes being properly lined up, a sliding internal spindle equipped with a tapered guide is used with the tap as shown in the cut below.



Prior to tapping the first or outer hole, the spindle is moved forward until the tapered pilot seats in the second or inner hole, and, as the tapping operation proceeds and as the tap advances, it operates in true alignment. After completing the first hole, the spindle is removed, and in tapping the second or inner hole, the unfluted thread section, back of the fluted section, screws into the first hole, thus acting as a guide for the second tapping operation. Spindle Staybolt Taps are regularly furnished with 12 threads to the inch.

Straight Boiler Taps

STRAIGHT BOILER TAPS, used in Boiler, Locomotive and Railroad Shops, are, strictly speaking, only a special class of Hand Taps. They have 12 threads to the inch and range in size from $\frac{1}{2}$ " to $1\frac{1}{2}$ ", inclusive.



★ "GREENFIELD" TOOLS ★

The threaded portion as shown on the previous page, is preceded by a pilot section to insure easy starting. Straight Boiler Taps differ from regular Hand Taps in that the shank diameters of all sizes are the same as the basic major thread diameters.

Taper Boiler Taps

TAPER BOILER TAPS, used for tapping holes where a steam-tight fit is required, are similar in design to Straight Boiler Taps, insofar as overall and shank diameters are concerned. Their threaded portions, however, are tapered and they have no pilots as will be noted from the following cut.

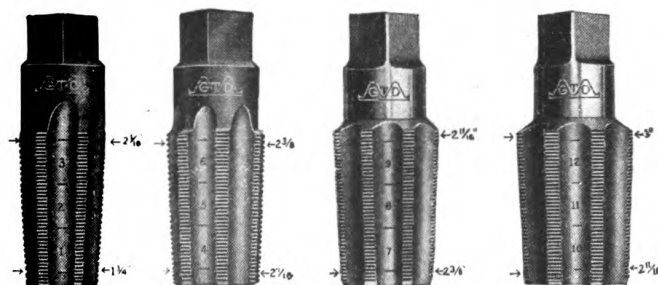


The taper is $\frac{3}{4}$ inch to the foot and the diameter of the tap is measured $\frac{5}{8}$ inch from the large diameter of the thread.

Mud or Washout Taps

THIS type of tap, used principally in Boiler, Locomotive and Railroad Shops, is designed for tapping mud plug holes, located at the lowest part of the water system of locomotive boilers. They provide a means for draining foreign matter from the system. The plugs, fitting into these holes, have tapered threads, which insure water-tight fits. The taper, $1\frac{1}{4}$ inch to the foot, is incorporated in the threaded portions of the taps.

When it becomes necessary to drain boilers, the plugs are removed, and since the plug seats are usually rusty and damaged, it is customary to re-tap and replace the plugs with the next larger sizes, otherwise, water-tight fits would not be obtained.



The cuts above show four sizes of taps that make up a set. Each tap is marked with three numbers in the flute which indicate the three different size holes that can be cut with it. The original mud plug hole is tapped with the smallest tap, marked in the flutes 1, 2 and 3, the tap stopping at the second line in the flutes. When it becomes necessary to re-tap, the tap is run in up to the third line. This process would be repeated until the entire 12 sizes incorporated in the four taps were used. These taps are regularly furnished with 12 threads to the inch.

Ground Thread Taps

MASS production methods, with the ever-present desire to lower manufacturing costs, have necessitated definite tolerances for certainty in assembly of threaded parts.

To meet the varying degrees of accuracy required in producing various types of threaded parts, it became necessary to adopt certain standardized working tolerances as a basis for machining operations. These working tolerances are divided into classes of fits, known as loose fit, Class 1; free fit, Class 2; medium fit, Class 3; and close fit, Class 4. Under this standardization, the pitch diameter of a $\frac{1}{2}$ -13 N.C. tapped hole, for example, can measure from basic to .0074" over basic for a Class 1 Fit, allowing a working tolerance of .0074". The working tolerance for the $\frac{1}{2}$ -13 N.C. tapped hole in a Class 2 Fit is .0052", for a Class 3 Fit .0037", and a Class 4 Fit .0019". (See Pages 48-49 and 118-119 for tables showing classes of fits.)

Prior to this standardization of working tolerances, taps were not required to produce such accurately tapped holes, particularly in the closer limits. Furthermore, many difficulties were encountered in the manufacture of taps that would maintain the size limitations called for by the closer fits. The main problem that had to be solved was elimination of steel distortion which caused lead error when the taps were hardened. What this did to the threaded part is illustrated by the cut shown below.



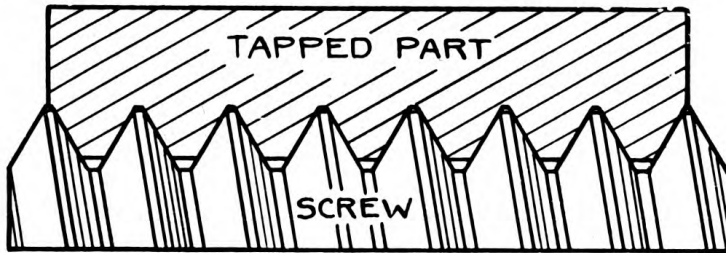
A Poor Screw Thread Assembly, Due to Lead Error in Tapped Part

It will be noted from this illustration that the tapped part contacts a screw on two threads only. This results in a weak assembly. Other errors in lead cause similar uneven contacts which are not acceptable in present day practise.

As time went on most lead error difficulties were overcome by the more scientific heat treating methods that were evolved, but complete elimination of lead error as an assembly factor was not accomplished until the advent of the Ground Thread Tap, a tap which, as the name implies, is produced by grinding the threads in the tap blank after it has been hardened.

Ground Thread Taps—Continued

The following sketch shows a screw thread assembly with the tapped part contacting every thread of the screw. The thread in the tapped part was produced with a Ground Thread Tap. Such perfectly tapped holes are no longer produced haphazardly, but are assured by the use of Ground Thread Taps.



A Correct Screw Thread Assembly, Due to Absence of Lead Error in Tapped Part

During the early stages of thread grinding, both carbon and high speed steel taps of standard sizes and pitches were ground and carried in stock, but it developed later that the high speed type was the most economical, and now practically all Ground Thread Taps are made from High Speed Steel. These are divided into two types — Commercial Ground and Precision Ground.

The Greenfield Tap and Die Corporation was first to develop and place on the market, Commercial Ground Thread Taps at moderate prices, under the trade name, "Tru-Lede". Our Commercial Ground Thread Taps are now identified by a single ring around the shank, in addition to the name "Tru-Lede". They are held to a small tolerance on the pitch diameter, ranging from .001 to .002 depending on the pitch diameter, but the main feature is a close lead tolerance of plus or minus .0005" in one inch of thread as against a lead tolerance of plus or minus .003" for the cut thread (not ground) type of tap. The shanks of "Tru-Lede" Taps are also ground concentric with the threads. This eliminates wobbling and cutting oversize due to eccentricity.

Precision Ground Thread Taps are similar to the Commercial Ground except that they are held to closer pitch diameter tolerances, generally .0005". There are three optional pitch diameter limit zones for Precision Ground Thread Taps, No. 01, 1 and 2. The following listing explains how the pitch diameter tolerances are applied to the various limits.

Pitch Diameter 01 Limit — Basic to basic minus .0005"

Pitch Diameter 1 Limit — Basic to basic plus .0005"

Pitch Diameter 2 Limit — Basic plus .0005" to basic plus .0010"

While, generally speaking, Ground Thread Taps are used to produce threaded parts to close tolerances which cannot be held by the less accurate Cut Thread Taps, because of their clean, accurate thread surfaces, they produce so much better threads that they will also prove more economical to use than High Speed Cut Thread Taps.

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Acme Thread Taps

TAPS for cutting Acme Threads are usually of a special nature, requiring individual consideration, so each tapping job becomes an engineering problem of its own; therefore, when ordering Acme Thread Taps it is very important to furnish the manufacturer sketches or blueprints of the taps required, samples of the parts to be reproduced, or other details of threads to be cut. Information of this kind is an invaluable aid in designing taps suitable for a particular requirement. Many Acme Thread jobs can be handled satisfactorily with a single tap whereas others require two or more taps. The number of taps required depends entirely upon conditions such as: Depth of hole, material, coarseness of pitch, etc. We, therefore, cannot stress too strongly the necessity of furnishing all the information requested on Page 62.

When the "Acme" Thread was originally designed, its chief purpose was to replace the "Square" Thread, and a number of other thread forms, which were difficult to manufacture with uniform accuracy. The advantages of the Acme Thread soon became manifest, and its adoption became widespread, until today it has practically replaced the former square, and other similar threads used in the manufacture of Feed and Operating Screws for machine tools and other types of mechanism.

The substitution of finer pitches, especially in the smaller size range, is a more recent improvement affecting Acme threads. In this connection, the National Screw Thread Commission in its 1933 report has suggested, as a tentative specification, the following pitches for specific screw and nut sizes.

Size	Threads Per Inch	Size	Threads Per Inch
$1\frac{1}{4}"$	16	$1\frac{1}{4}"$	5
$\frac{5}{16}"$	14	$1\frac{3}{8}"$	5
$\frac{3}{8}"$	12	$1\frac{1}{2}"$	4
$\frac{7}{16}"$	12	$1\frac{3}{4}"$	4
$\frac{1}{2}"$	10	2"	4
$\frac{5}{8}"$	8	$2\frac{1}{2}"$	2
$\frac{3}{4}"$	8	$3\frac{1}{2}"$	2
$\frac{7}{8}"$	8	4"	2
1"	5	5"	2
$1\frac{1}{8}"$	5		

"Acme" Thread
Roughing Tap

"Acme" Thread
Finishing Tap

Acme Thread Taps—Continued

These tentative specifications seem to be very desirable but among the users of Acme threads, the impression still prevails that the coarser the pitch the greater the bearing area, that is, surface contact on the sides of the thread. As a result of this, Acme pitches specified by some users are entirely too coarse for the screw diameter, which in turn tends to make the tapping of the part engaging the screw more difficult. If it were generally realized that the bearing area on an Acme Thread increases as the pitch becomes finer for a given diameter, this condition might improve, so, for the benefit of Acme Tap users, we suggest the adoption of fine pitches whenever possible. This will assure greater strength in the taps and improve tapping conditions. For example, let us consider a $1\frac{1}{4}$ inch diameter screw with 4 Acme Threads to the inch, which is still commonly used. If the thread in the part engaging this screw were one inch long, we would have a bearing area of 1.4185 square inches, whereas if the pitch were five threads instead of four, the bearing area would be 1.4559 square inches. Similar increases in bearing area would result with still finer pitches; consequently, nothing is gained by a coarse pitch insofar as bearing surface is concerned.

If, of course, the coarse pitch is desired for greater travel in a given number of revolutions of the screw, equivalent results can be obtained by substituting a double thread which would still permit the use of a finer pitch and maximum bearing area.

In considering this substitution the single thread may look stronger because the individual teeth are larger, but analysis shows some facts that are not apparent at first glance, as illustrated in Figs. 1 and 2 below:

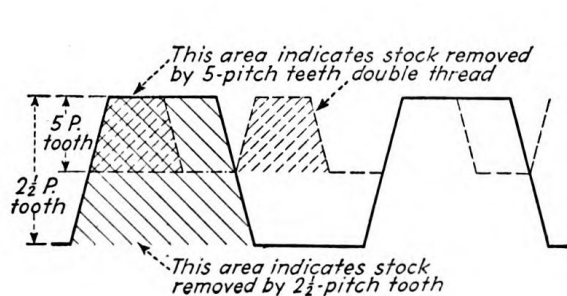


Fig. 1

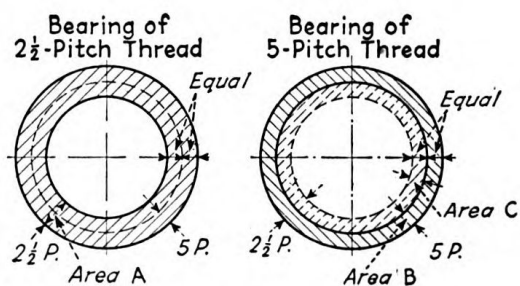


Fig. 2

Fig. 1 — More stock must be removed when cutting a single thread than for a double thread to meet like conditions. Fig. 2 — A comparison of bearing areas shows considerable advantage in favor of the double thread

Fig. 1 represents a 5-pitch double thread superimposed on a $2\frac{1}{2}$ -pitch single thread. Both screws have the same lead and the same diameter. The Acme thread illustrated is commonly used in lead screws, feed screws and valve stems.

It will readily be seen that the single thread design is the weaker of the two. More metal has been removed from both the screw and the nut. This removal, in addition to weakening both members makes the threads more difficult to cut. For the single thread construction the screw has a smaller root diameter.

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Fig. 2 shows cross sections of both screws to compare the respective bearing areas. Since the $2\frac{1}{2}$ -pitch thread is twice the depth of the 5-pitch thread it is obvious that:

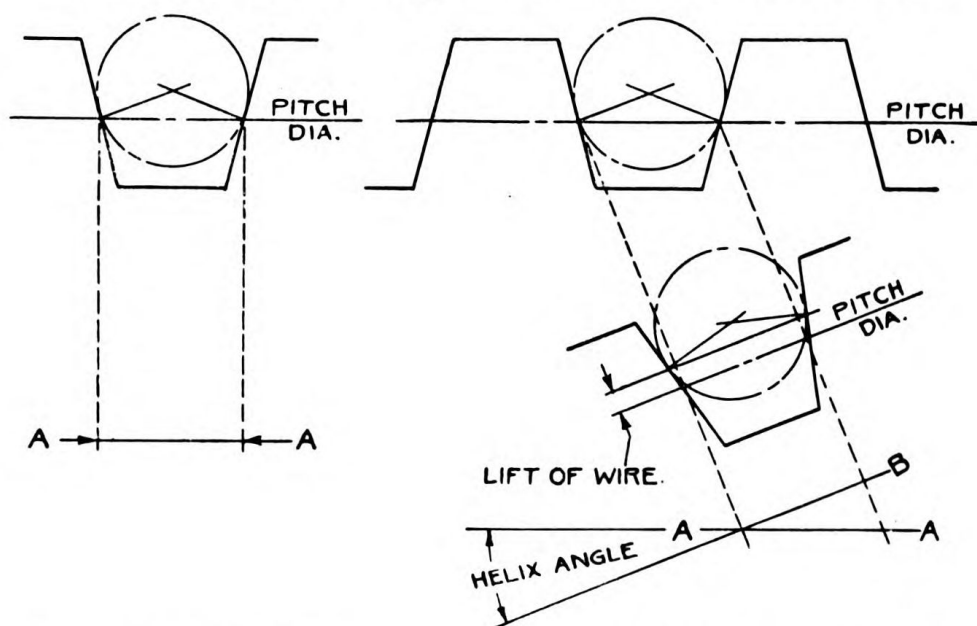
Area A equals Area B plus Area C *and*
Area B is greater than Area C

Therefore, twice Area B is greater than Area A, and the 5-pitch double thread gives greater bearing area because of the larger minor diameter (in this case seventeen per cent more bearing).

While in general Acme threads on screws are much coarser than the American National Standard thread (60°) for screws of equivalent sizes, it is well to consider what effect the helix angle of the thread has on the wire measurement of the screw. Usually, on Acme Thread Taps, a correction has to be made to compensate for this condition and if a similar correction is not taken into consideration when threading the screw, the latter will be too loose in the tapped part.

If we refer to pages 56-59 covering the subject of "Measuring Taps", we find a formula for calculating the helix correction which must always be considered when the correction is more than .00015". The reason for helix angle correction can best be visualized if we consider taking a 29° threading tool and, on a lathe, cutting an annular groove in a piece of steel. If we lay a wire in this groove, the axis of the wire will be at right angles to the axis of the piece of steel and a line through the points of contact with the side walls is likewise parallel to the axis of the steel.

Effect of Helix Angle on Wire Measurements



A-A = $\frac{1}{2}$ pitch or width of space at pitch line and is always measured in an axial plane regardless of helix angle.

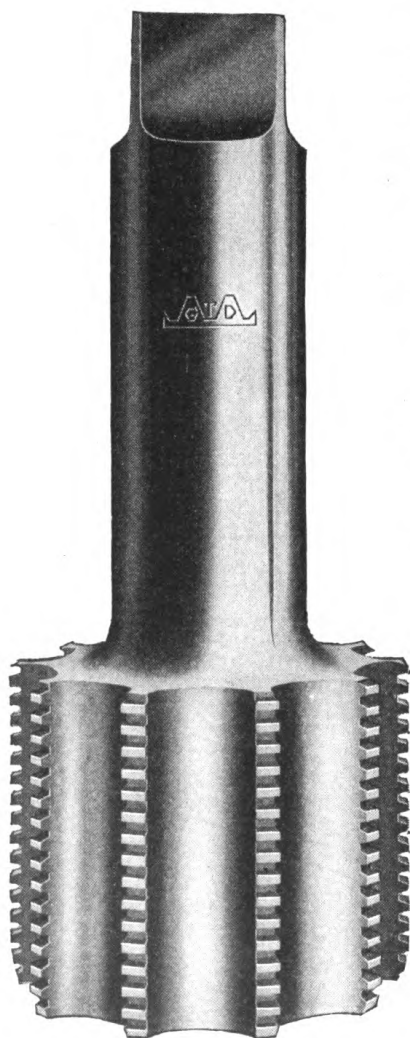
A-B = Width of space at pitch diameter in a plane normal to thread groove becomes narrower than A-A.

Acme Thread Taps—Continued

Now, without disturbing the setting of the tool, and using the same tool, we gear up the lathe to a 4-pitch screw, cutting a thread therewith to the same depth as the annular groove was cut.

When we lay the wire in the 4-pitch thread, we find that a line through the points of contact with side walls is no longer parallel to the axis of the steel, but at an angle thereto because the 4-pitch screw thread is a helix and produces a helix angle to the axis of the screw. Although the same tool was used, the groove in which the wire lays is narrower than it was before, due to the twisting helix, and consequently, the wire is lifted, which would give a false wire reading if the measurement did not take into consideration the correction for the helix angle. If, with the same tool and setting a double thread were cut, (i.e. $\frac{1}{2}$ " lead) groove would be still narrower and the wire lifted more.

The foregoing should help to explain why excessive helix angles in all screw threads must be considered in the wire reading. The greater the angle, such as a 90° included angle, the less is the interference, and the smaller the angle, as we approach the 29° Acme and less, the greater the interference.



A 10" Acme Ground Thread Tap

Weighing more than 250 pounds, this (we believe) is the largest Ground Thread Tap ever made — a good example of "Greenfield's" ability to turn out "specials" to meet the most exacting demands of industry.

Part II

FACTORS GOVERNING THE PROPER SELECTION AND USE OF TAPS

UNLIKE Part I, which describes the elements and functions of the various types of taps, Part II consists of a series of articles, each more or less independent in itself. These articles outline all of the Principal Factors Governing the Proper Selection and Use of Taps for Mechanical Tapping, from the Type of Tapping Equipment and Tap Holding Devices employed to the Measuring of Tapped Holes.

In addition, it contains an article on "Measuring Taps," which we believe the student of tapping will find interesting and instructive. The article headed "Trouble Sources in Tapping," may also be used as a guide for locating the sources of tapping troubles encountered from time to time.

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Type of Machine Available and its Mechanical Condition

THE type of machine available, its mechanical condition, its adaptability, etc., all have a marked influence on successful tapping operations. As an example, the choice as between carbon or high speed steel taps is more or less dependent upon the machine's speed capabilities. There are many other factors, of course, that should be checked in ascertaining that the best possible tapping condition is employed, and that the cost per tapped hole has been reduced to a minimum.

The following are some of the points to consider in studying this condition.

1. Is the weight and size of the machine in proportion to the work and size of tap required, i.e., not too light or too heavy? Generally, for light tapping operations, a small fast machine is recommended, while for large work a heavier machine will be found more successful.
2. If the machine is to be used for a variety of sizes, does it have sufficient speed changes to properly take care of the different sizes in order that the taps may be operated at their recommended speeds?
3. Is the machine properly powered to insure uninterrupted power transmission during the tapping operation?
4. Is the spindle in good condition and alignment, free to traverse without undue effort, yet fitted closely enough to exclude all vibration?
5. Is the work table true (when tapping vertically) and at right angles to the spindle within a comparatively close tolerance?
6. Are the ways (when tapping on a screw machine or turret lathe) in good condition and well lubricated to eliminate excess load or drag? Are the turret bed gibs sufficiently tight to prevent side motion and do the turret holes line up with the spindle?
7. Is the reverse mechanism sufficiently sensitive to give instantaneous action?
8. Are all belts sufficiently tight and free from oil to insure proper and continuous transmission of power?
9. In the case of a hand machine, is the feed handle of proper length for convenient manipulation? Excessive length tends to place additional leverage on the tap, which does not speed up production, but tends to cause excessive lead error and often loading of the tap. Breakage is not uncommon where too much leverage is applied.
10. Is the spindle of the machine properly counterbalanced? Added accessories such as chuck, friction mechanisms, and tapping attachment increase the weight of the spindle. While the difference in spindle weight may not be

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sufficient to cause bad threads, a slight excess weight on the spindle may cause taps to cut oversize due to burnishing of one flank of the thread while backing out, and this too may result in loading of the tap in soft stringy metal, particularly, low carbon steel and brass. Therefore, if taps cut oversize for no apparent reason, and show a tendency to load when used on a machine where tapping attachments or heavy chucks have been added it is well to check the balance of the spindle.

The "Type of Machine" to select for a specific tapping job, therefore, is a matter of selecting the one with the equipment best fitted for the work, and keeping it in adjustment and repair so that its influence on the job will be only that of rotating the tap. However, for through hole tapping, a vertical type of machine would be preferable in many cases as it facilitates easier chip disposal than some types of horizontal machines not especially designed for tapping.

Tap Holding Devices

MUCH has been accomplished in recent years in developing tap holding devices or chucks. Manufacturers of such devices have studied and analyzed the requirements, and have designed chucks with "better tapped holes" as their ultimate goal.

Where maximum production and economy in tool costs are desired, these chucks or attachments are important factors. Experience and time have demonstrated thus far that the so-called "Friction-Type" chuck represents the best development in chuck design.

One of the features of these attachments is that their reversal speed is usually about double the forward speed, resulting in greater production. In addition, they have a very sensitive clutch mechanism which stops the rotation of the tap immediately when it meets with interference—this reduces tap breakage. A feature incorporated in some attachments which prolongs the life of the tap chamfer, permits the tap to idle in the forward motion and not in the reverse. Consequently, the tap starts to cut immediately upon entering the hole, avoiding damage to the cutting edge of the tap's chamfer which may happen where the tap idles in reverse and hits the work in the reverse motion.

Attachments for increasing the tapping speed on slow speed machines are also available. These have a gearing arrangement which gives the chuck holding the tap a higher speed than that of the spindle in the machine.

Frequently, special holders are made to suit some particular requirement. Preferably such designs should provide for the application of standard stock taps. Special taps are considerably more expensive than standard taps, and, in addition, there is usually a delay in procuring such tools, as they must be made

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up special. Sometimes, however, regular stock taps can be altered by reducing the shank to fit some particular holder, and, while there is nothing wrong with such a procedure, it is important that the reduction, which is accomplished by grinding, be handled mechanically. The grinding operation, in other words, should be handled the same as any other cylindrical grinding job, between centers, to insure concentricity between the shank and threaded section. Grinding should not be attempted by hand, as it cannot be done accurately. If a tap is held by a shank that is excessively out of round, tap breakage, short life and poor tapped holes are bound to result.

Physical Properties—High Speed and Carbon Steel Taps

A MAJOR development affecting taps in general was the introduction of the use of High Speed Steel for taps early in the twentieth century. Prior to this time all taps were made from carbon steel. It was found that taps made from this new steel were capable of performances undreamed of by the use of carbon steel taps. With the development of new heat treatments and improved heat treating equipment, greater toughness and wearing qualities were imparted to the taps. As a result of these achievements, High Speed Steel Taps today can be operated at about double the speed of carbon taps, and, in some instances, more than double.

High Speed Steel Taps have also made it possible to tap many of the new alloys developed in recent years, some of which cannot be tapped successfully with carbon steel taps.

In view of these greatly improved performances, the question might be raised, "Why not discard carbon steel taps altogether?" This is a perfectly natural question, but even High Speed Steel Taps have their limitations. Inability on the part of the machines usually available, to transmit the higher speeds at which High Speed Steel Taps operate most successfully seems to be the main handicap to their exclusive use. We have seen innumerable instances where High Speed Steel Taps were being run too slowly and would not perform satisfactorily until accelerated to the required higher speeds. Of course, it is not always possible to increase speed as there are still many thousands of machines in daily use that were not designed for the higher operating speeds. This is especially true of many screw machines. For requirements of the latter type, carbon steel taps are more economical, particularly since most carbon steel taps today are made from specially selected steel capable of far better performance than were the carbon steels of former years.

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To understand, more clearly, some of the differences between carbon and high speed steel tools, it is well to consider some of the fundamental properties of steels. Principal among these are:

1. Chemical composition
2. Hardness
3. Toughness
4. Wear or Abrasion-Resistance
5. Thermal or Heat-conductivity

CHEMICAL COMPOSITION: Without going into technical details, it is probably sufficient to say that carbon steels, as a rule, contain only carbon, iron, and small percentages of other elements added for a definite purpose in manufacturing, but in such small amounts that they are not considered as alloying elements. The total of elements other than carbon and iron in a straight carbon tool steel seldom exceeds one per cent in weight while in a high speed steel the alloy content may be as high as 30 per cent.

These elements in high speed steel consist principally of tungsten, chromium, vanadium, manganese, molybdenum, and sometimes cobalt. Added in proper proportions, these alloys produce a more stable condition in the steel with ability to resist heat, and abrasive contact.

HARDNESS: If we consider hardness merely from the standpoint of any of the conventional methods of testing (Rockwell, Brinell, Scleroscope, etc.) there is really no basis for choice between a hardened carbon tool and a hardened high speed tool. A Rockwell Hardness of C-63 might or might not indicate satisfactory heat-treatment in either type of steel and it could be demonstrated quite readily that under certain conditions a carbon tool of Rockwell C-62 would be far superior to a similar high speed tool of Rockwell C-65.

The user of taps and other tools is cautioned, therefore, to avoid specifying a definite Rockwell Hardness for any type of tool. This should be left to the judgment of the manufacturer who understands his own steels and their response to treatment.

The property of "red-hardness" in high speed steel is the ability of that steel to retain its hardness even though the tool is heated in use up to a dull red heat. Straight carbon steels do not have this property.

TOUGHNESS: Generally speaking, toughness is a measure of the resistance of the steel to torsional (twisting) stresses or to impact (sudden blow) stresses or to a combination of both. While there is still much to be learned about such stresses and their measurement, it may be stated briefly that results of various methods point to carbon steels as being somewhat tougher than high speed steels, assuming that both have been properly heat-treated.



Physical Properties of Taps—*Continued*

WEAR OR ABRASION RESISTANCE: While there are no standardized methods for the determination of this factor, a number of investigators have shown that high speed steels, as well as other steels of similar structure, are definitely superior to carbon steels even for applications where cutting ability is disregarded. Typical of these applications are bending-mandrels, broaching punches, blanking dies, and forming rolls.

THERMAL OR HEAT CONDUCTIVITY: The Thermal Conductivity of elements or alloys is a well-defined mathematical quantity which is a measure of the ability of that element or alloy to transmit heat. It can be readily seen how this property would affect the cutting efficiency of a tool. Even though the tool might be operating under a flood of oil or other coolant, the cutting edges are being heated rapidly by friction of the tool against the material being cut, so, unless this heat is carried away quickly, heating of the tool becomes progressive and the cutting edges become dull.

With carbon tool steels, the Thermal Conductivity remains constant or decreases as the temperature of the cutting edge approaches the temperature at which the tool was tempered. That is, if a carbon tool was originally tempered by the manufacturer at a temperature of 430 degrees Fahrenheit, for example, then as the tool is put into service and the friction of cutting heats the tool up to that temperature, the Thermal Conductivity of the carbon tool remains constant or decreases. As the tool is heated still further the Thermal Conductivity decreases rapidly, and, because of the inability of the tool to carry the heat away, further tempering of the tool takes place resulting in soft cutting edges.

In the case of the high speed steel, however, as the heat developed by friction raises the temperature of the cutting edges, no change in Thermal Conductivity or hardness takes place until the original tempering temperature (1050 F–1120 F) has been reached and then the Thermal Conductivity *increases* and the cutting edges carry away the heat rapidly enough to prevent breakdown.

Of course, there is a limit to the safe operating temperatures for high speed steels and when this limit is exceeded, a high speed tool will fail also. However, the fact that a high speed tool may be operated safely at 600 or 700 degrees F hotter than a carbon tool is the simple explanation of why high speed tools should be operated at speeds high enough to produce a moderate rise in temperature.

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Nature of Materials to be Tapped

THE material used in parts to be tapped is a very important factor entering into "Proper Tap Selection" for mechanical tapping. Too frequently, the user of taps does not realize what a decisive influence a certain material has on the tap. Therefore, it seems fitting to cite a few examples which will show the importance of this factor in successful tapping.

To begin with, let us consider one of the most widely used of metals — cast iron. Here is a metal that has a very abrasive action on taps. Therefore, High Speed Steel Taps should be used, because of their superior ability to resist abrasion. Taps with "Maxi" finish have been used successfully in many cases.

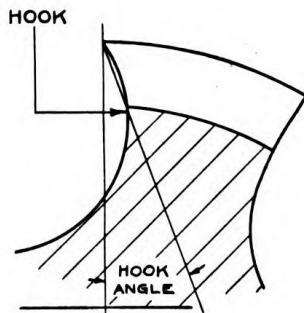
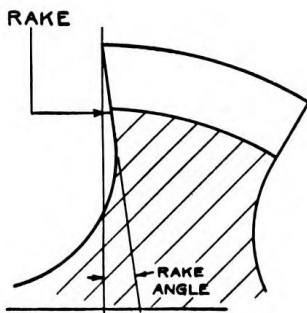
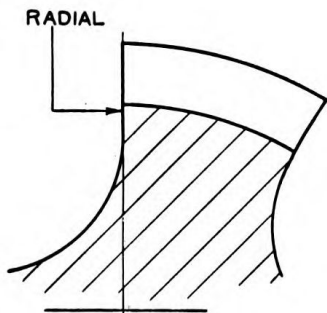
On the other hand, when tapping in brass, first consideration should be given to speed because brass machines freely; therefore, taps can be operated at high speeds. If the speed available is sufficiently high to employ high speed steel taps at their recommended speeds, then they should be used, otherwise carbon steel taps are suggested.

In the case of copper, either carbon or high speed steel taps can be used, the selection again being entirely dependent upon available speeds.

Steels present a still different condition — the majority of these can be tapped only with high speed steel taps except machinery and certain types of tool steels which can be tapped with carbon steel taps.

The shape and angle of the cutting face of a tap in many cases influence its performance in certain materials, and since no tap can be made to work successfully on production in every material, it is desirable sometimes to alter its cutting face design or angle.

There are three types of cutting faces usually incorporated in tap designs, namely — Radial Face, Raked Face and Hooked Face. These three designs are shown below and further explanations of the terms Rake and Hook are given on pages 9 and 11.



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Nature of Materials to be Tapped—Continued

Naturally, stock taps are provided with a flute and cutting face design which experience has proven to be best adapted for the majority of tapping requirements including both metallic and non-metallic types. Some of these are listed below:

Machinery Steel	Bronze*
Cold Rolled Steel	Bakelite
Brass*	Beetleware
Cast Iron	Celluloid
Malleable Iron	Fiber
Pipe Fittings (Cast Iron	Pyroxlyn
Malleable Iron, or Brass)	

Cutting faces of taps for cast iron, malleable iron and brass are usually radial; however, a rake of 3°–5° is sometimes desirable.

Such materials as Cast Steel, Manganese Steel, Molybdenum Steel, Vanadium Steel or Steel Pipe fittings will invariably tap better when the cutting face of the tap has up to a 10°–15° rake. Cast Aluminum, Die Cast Metal (Lead, Zinc or Aluminum), Duralumin, Herculoy, Molychrome Steel, Nickel-Chrome Steel, Allegheny Metal, Monel Metal, Ambrac (70% copper), Rolled Aluminum, Rubber (hard) and certain Stainless Steels tap better with a hook up to 10°–15°, whereas Babbitt, Bronze (aluminum), Copper, Duronze (copper) and Nickel Silver can be tapped better with a tap having up to a 20° hook.

The size of the tap must also be considered as it has been found by experience that in a given material, hook or rake angles of the cutting faces must be varied according to the size, depending upon the strength of the lands.

When special taps are ordered for use in any of the materials requiring a 10 to 15° rake or up to a 20° hooked cutting face, such designs are incorporated in the milling operation of the flute by means of special cutters. However, if a stock tap is altered to one of the latter designs the change is best accomplished by grinding. Our recommendations on this grinding operation are given on page 53 under the heading "Re-Sharpening and Grinding."

Materials of an abrasive nature that tend to prematurely wear the tap under-size should be tapped with our "Maxi" High Speed Steel Taps.

*When tapping these materials, it is also desirable to narrow the lands of the tap approximately as follows:

3	land	tap	—	land	width	=	1/8	of	tap	diameter
4	"	"	"	"	"	"	1/16	"	"	"
5	"	"	"	"	"	"	1/32	"	"	"
6	"	"	"	"	"	"	1/64	"	"	"
8	"	"	"	"	"	"	1/128	"	"	"

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"Maxi" Finish for High Speed Steel Taps

THERE are various metals and compositions, which, due to their basic structure have abrasive characteristics that subject any cutting tool to excessive wear. Taps are no exception, but, to combat the wear caused by abrasiveness, "Greenfield" has developed a special surface treatment for High Speed Steel Tools, known as "Maxi" Finish, which makes them extraordinarily resistant to wear when working in tough or abrasive materials.

"Maxi" Taps with this special surface treatment or finish are ideal for tapping aluminum, cast brass, bakelite, cast iron, malleable iron, fiber, hard rubber and other materials and compositions with gritty or abrasive characteristics that subject ordinary High Speed Tools to excessive wear, and soon destroy their accuracy and efficiency.

While developed primarily for use in the above mentioned materials, they have given excellent results in a variety of other materials, and we invite users to try them on difficult production jobs.

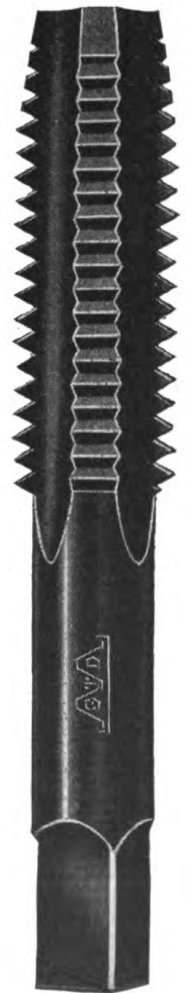
They have produced some amazing results during the past few years in hundreds of plants in the United States, and there have been numerous cases where "Maxi" Taps have increased production by 300% or more.

Another noteworthy feature of "Maxi" Taps is their ability to operate at higher speeds than High Speed Steel Taps, not so treated. Suggested "Maxi" speeds are given in the table on page 52.

"Greenfield's" "Maxi" surface treatment or finish is not confined to High Speed Steel Cut and Ground Thread Taps, but can also be applied to other High Speed Steel Tools such as drills and reamers.

The "Maxi" Finish is applied to all types of High Speed Steel Taps, Drills and Reamers, shown in our Standard Catalog, at no extra cost.

All "Maxi" Tools are identified by their jet black finish.



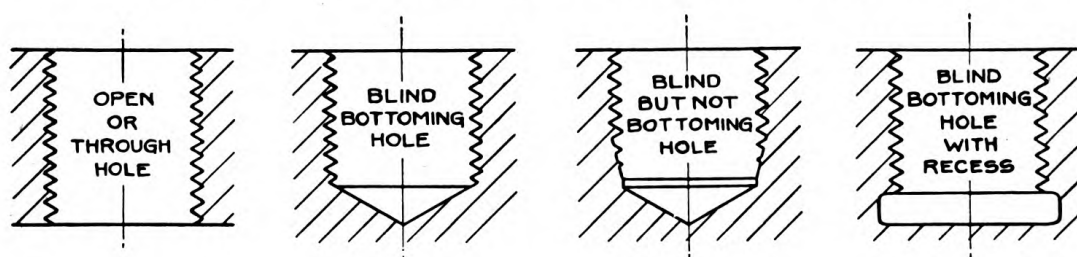
"Maxi" Taps are identified by their jet black finish.

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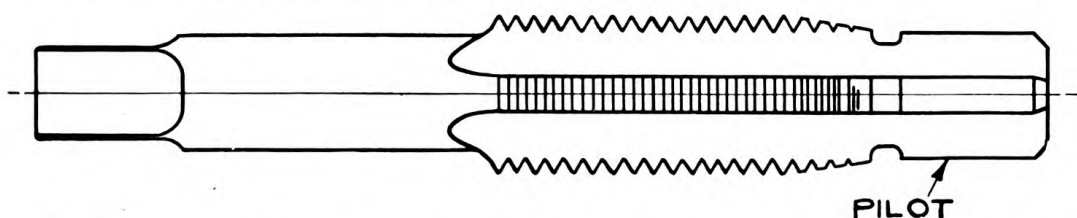
Preparation of Holes for Tapping

BECAUSE the tapping operation follows the drilling operation, there is a tendency on the part of some drillers to overlook the importance of properly drilled holes on the subsequent tapping operation. Yet for the tapping of high quality threads, particularly at production speeds, properly drilled holes are of vital importance, and it should be borne in mind that the tap is not a corrective for poorly drilled holes.

Generally considered, there are two types of holes — open or through, and blind or bottoming. Depending upon the type of material, the class of fit, and the method of tapping, the following styles of hand taps are used for open or through hole tapping when this type of tap is adaptable. In steel and other types of malleable material, tapped by machine, the "Gun" and Plug Tap are most commonly used. For cast iron and non-malleables, the Plug Tap produces best results. Some holes may be considered blind and yet not bottoming, for the reason that it may be possible to drill the hole considerably deeper than it is necessary to tap. In such cases it is possible to proceed as for through holes, using the same style of tap as would be used if the hole were really a through one. However, if the thread must extend to the very bottom of the hole, a Bottoming Tap should be used.



In all cases and in all types of holes, good clean drilling and a reasonable degree of size maintenance will add considerably to the ease of tapping good threads, and will make for better size control, will often prevent loading of tap threads, and will lessen the strain on the tap.



Quite frequently, taps of special design are provided with pilots, preceding the threaded section, for the purpose of maintaining alignment.

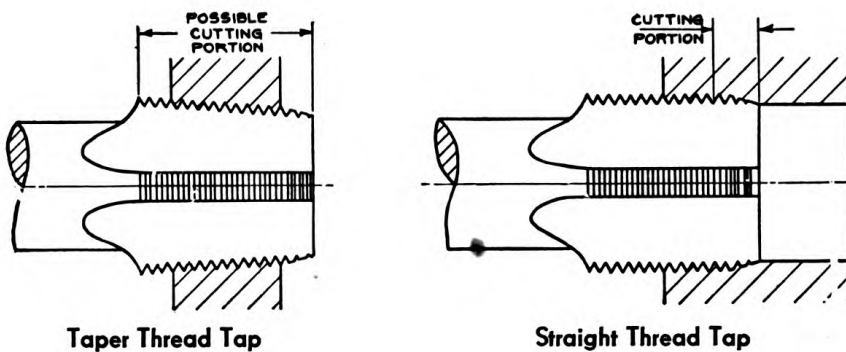
Controlling the size of drilled holes for such taps is most important because holes looser than a free fit for the pilot size defeat the purpose of the pilot, while

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tight holes add unnecessary, if not excessive, load to the tap. "Go" and "Not Go" Plain Plug Gages for controlling the size of drilled holes are a good investment where taps with front pilot are required. Such gages are also a worth-while investment for other drilled holes to be tapped in production quantities.

Of equal importance when tapping to the bottom of a hole is the matter of clearing out the drill chips, or other accumulated material before starting to tap. Tap breakage frequently results from the impact of the tap upon a bed of drill chips at the bottom of the hole.

Another type of hole that frequently presents difficulties in tapping, is the one prepared for tapered threads. When tapping with a tapered thread tap such as a Taper Pipe Tap, it should be borne in mind that every tooth of the tap in the hole is cutting, whereas with a straight thread tap only the chamfered portion and the first full thread does the cutting, the remainder of the straight threads acting only as a guide or follower.



Naturally, the tapered thread tap carries a much greater load which increases as the tap advances. To lighten this load, the hole should be bored or reamed taper before tapping. If holes for taper pipe threads are reamed with standard taper pipe reamers before threading, the tap will only be required to cut away the full depth of thread.

It is generally understood today that the size of a drilled hole, prior to tapping, should be large enough to produce a thread depth of approximately 75%. Tables showing the commercial sizes of drills to produce such thread depths or the nearest equivalent sizes have been prepared by the various tap manufacturers, and many tap users follow the recommendations in these tables in preparing holes for tapping. (See Tables 351, 352, 353, 354 and 355, pages 102 to 111 inclusive.) Lower power consumption and less tapping troubles are the two major reasons which prompted adoption of the 75% thread depth because it has been proven that in tapping a full or 100% thread depth, about three times more power is necessary than when tapping a 75% thread, yet the former is only about 5% stronger.

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Preparation of Holes for Tapping—Continued

A great deal of data was collected and published in this connection by the National Screw Thread Commission, which, for a number of years, was affiliated with the Bureau of Standards at Washington, D. C., but whose work is now carried on by the American Standards Association. Their latest publication ASA B1.1 — 1935 permits a tolerance on minor hole sizes which produces a thread depth as small as 53% for the smaller sizes but no more than $83\frac{1}{3}\%$ on any size.

This, of course, represents quite a variation, but a definite thread depth for all sizes, and under all conditions, is not practical. Therefore, the tap user must determine for himself what is best for his particular requirements, but, by analyzing the following subjects, the problem can be very easily solved.

1. Diameter and Pitch of Tapped Hole
2. Nature of Material being Tapped
3. Depth of the Tapped Hole

As to the first consideration, "Diameter and Pitch of Tapped Hole," let us consider whether the tap required has a fine or coarse pitch in relation to its size, bearing in mind that the coarser the pitch the smaller the thread depth should be. It is our suggestion, (assuming the design of the tap is correct for the requirement at hand), that the 75% thread depth be tried first, and, if this results in tap breakage, the thread depth should be reduced gradually until satisfactory conditions are produced. In doing so, the question may arise, as to whether such a reduction might possibly jeopardize the strength of the thread. This can also be readily determined for we know that a nut with only 50% thread depth, made to standard specifications, will break the bolt before it will strip the threads.

It is also well, at this point, to consider some of the basic peculiarities that exist in our threading system so that we may better understand why tapping problems arise from this source. For example, the table below covering a group of tap sizes in the National Coarse and National Fine Thread Series, shows what percentage the double thread depth is in relation to the basic major diameter, and plainly reveals that the smaller the tap the greater the thread depth proportion.

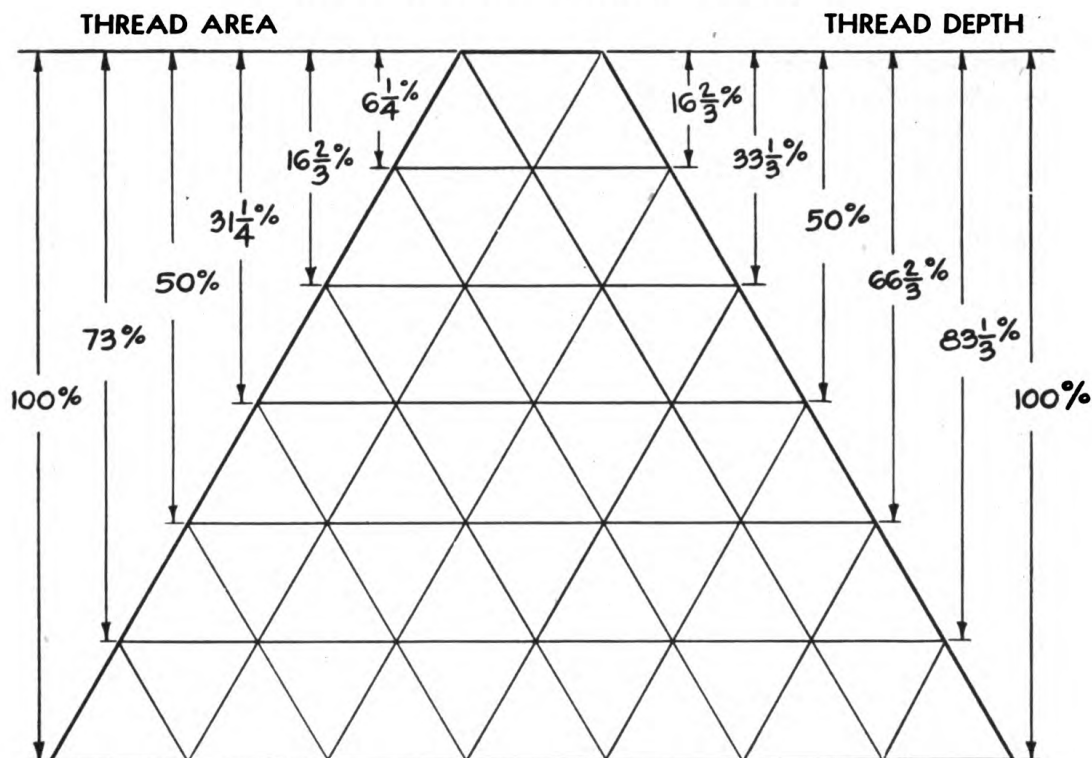
<i>Basic Major Diameter</i>	<i>N.C.</i>	<i>N.F.</i>
1"	16%	9%
$\frac{3}{4}$ "	17%	11%
$\frac{1}{2}$ "	20%	13%
$\frac{3}{8}$ "	22%	14%
$\frac{1}{4}$ "	26%	19%
#5 Machine Screw	32%	26%

After fluting suitably for this thread depth, weakness develops rapidly as the taps grow smaller; therefore, more care should be exercised when using small taps.

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Another interesting fact, illustrated by the chart below, is that, as the thread depth decreases, a still greater decrease is effected in the thread area. An $83\frac{1}{3}\%$ thread depth for instance represents only a 73% area, a $66\frac{2}{3}\%$ thread depth means only 50% thread area, etc., consequently, a decrease in thread depth effects a still greater drop in the amount of material the teeth of the tap must remove which in the case of using coarse pitch taps is a very favorable condition.

Percentage Comparison of Thread Area vs. Thread Depth



Profile of American National Thread

Now as to the "Nature of Material Being Tapped," we should bear in mind that soft stringy metals such as copper, drawn aluminum, monel metal, nickel silver, etc., due to their malleable nature have a tendency to flow towards the crest of the minor diameter while being tapped; therefore, the minor diameter of tapped holes in these materials will be smaller after the tapping operation, and this condition should be taken into consideration when deciding upon the tap drill sizes for such materials.



Preparation of Holes for Tapping—Continued

The toughness and hardness of the material should also be considered. Some of the alloy steels and metals that are very tough or of a high hardness can be tapped more successfully with less than 75% of thread and where these characteristics exist the smallest thread depth possible should be adopted.

The "Depth of Tapped Hole" is also very important. When tapping holes to a depth of more than one and one half times the diameter of the tap, especially when using machine screw sizes, it will be found advantageous to use larger drills than the 75% type. Drills which will give a 50% thread will be found entirely satisfactory.

Certain punched holes in thin sheet metal often create occasional tapping difficulties such as loading, thus causing tap breakage. To understand the cause of this condition the reader must visualize what happens during the hole punching process. As an example, select a sheet of paper and punch a hole through it with a pencil. Then notice how on the underside of the sheet the paper has been pushed down. A similar condition exists when punching metal, for, when tapping, the tap, on its reversal, has a tendency to "pull in" the "flared" metal which in turn loads in the minor or root diameter of the tap. Naturally, as the loading increases, the strain on the tap is also increased and breakage follows unless proper allowance is made for this condition when determining the size of the punch, as, the larger the punched hole, the less tendency for the tap to load.

Cored holes in castings, also forged holes as in forgings, should be checked carefully for size. If the size of such holes is smaller than necessary to produce a 75% thread depth they should be reamed.

To figure the size of a hole prior to tapping, use the following formula:

$$\text{Hole size} = \text{Basic Major Diameter} - \text{Thread Percentage (2d)}$$

$d = \text{single depth of thread}$

EXAMPLE:

Find the hole size for a $\frac{1}{2}$ -13 NC tapped hole maintaining a 65% thread depth.

SOLUTION:

The basic major diameter for a $\frac{1}{2}$ " tapped hole in a decimal equivalent is .500".

The single depth of thread for a 13 National Coarse pitch according to the table on page 117 is .049963" or in round figures .050".

Twice this depth equals .100". Now 65% of this double depth equals .065". Deducting .065" from the basic major diameter of .500" leaves a hole size of .435".

The nearest commercial drill size for this hole specification is $\frac{7}{16}$ " or, expressed in a decimal figure, .4375 which is the size drill that should be used.

All other hole sizes for any desired percentage of thread depth can be computed on this basis. After computing a hole size, the nearest commercial size of drill should be selected.



Class of Fit or Permissible Tapping Tolerances

TO MEET the present day demand for interchange of threaded parts, tapped holes must measure within certain specifications. For this purpose, standard working tolerances were set up by the National Screw Thread Commission some years ago, and practically all industries now conform to these standards. The four classes of fits definitely established and their size limitations are given in the table on Pages 118-119.

A common source of confusion in tapping is failure to distinguish between CLASS of fit as applied to PRODUCT TOLERANCES and OPTIONAL PITCH DIAMETER LIMITS as applied to PRECISION GROUND THREAD TAPS. The cause of this confusion doubtless is the fact that both terms involve the use of a similar, but not identical, series of numbers, and that the corresponding numbers have no direct relationship.

CLASS of Work fits or "Screw Thread Assemblies" are:

- #1 — "Loose"
- #2 — "Free"
- #3 — "Medium"
- #4 — "Close"

Of the four established fits, Class 2 and 3 are most commonly used.

Optional Pitch Diameter LIMITS or TOLERANCES of Precision Ground Thread Taps are:

#01, #1, #2, and the Taps are so stamped.

The table on page 89 shows the Maximum and Minimum Limits for Precision Ground Thread Taps in these optional tolerances.

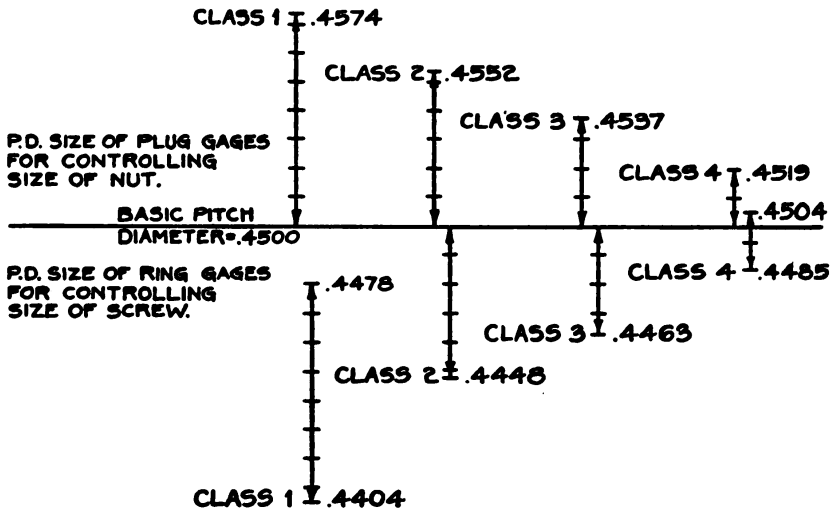
Ordinarily, when using Precision Ground Thread Taps it is best to determine what screw assembly fit is required, then the Tap to produce threads for that fit may be selected by trial from the optional tolerances available.

A graphic illustration of the four fits as applied to a $\frac{1}{2}$ -13 NATIONAL COARSE Nut and Screw is shown on page 48.

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Class of Fit or Permissible Tapping Tolerances—Continued

Size Limitations of $\frac{1}{2}$ -13 NC Nut and Screw For Class 1-2-3 and 4 Fits



The horizontal line represents the basic pitch diameter. The vertical lines the variable pitch diameter sizes of the screw and the nut. Divisions represent thousandths of an inch. Note in Class 1 the maximum size of the screw is below basic pitch diameter. In Class 4 it is above the basic pitch diameter. The minimum size of nut for all classes is the basic pitch diameter.

Suggestions as to the type of tap best adapted for producing Class 2 and 3 fits will be found in the table on the opposite page. As an example let us assume that it is necessary to tap a hole with a $\frac{1}{2}$ -13 NC tap and that a Class 3 fit is required. According to the specifications given in the chart above, the pitch diameter of a nut for a Class 3 fit may be from basic or .4500" to .4537" allowing for a working tolerance of .0037". Upon referring to the opposite chart we find that for a $\frac{1}{2}$ -13 NC Class 3 fit, a Commercial Ground Thread tap is recommended. This tap according to Table 326 on Page 87 has a pitch diameter of .4505" — .4515" which is well within this range. Therefore, under normal conditions, this tap should give the desired results, as it is .0022 under the maximum hole size and still sufficiently over basic to allow for wear.

In order to control the specifications of the various fits for tapped holes, the use of "Go" and "Not Go" Plug Thread Gages is recommended. These are described on Page 60.

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Selection of Taps for Class 2 and 3 Fits

TAPS specified in this table should normally produce the N.S.T.C. fits indicated in average material if used with reasonable care. The problem is one of selection. If specified tap does not give satisfactory gage-fit in the work a choice of some other grade of tap should be made. Grades may be considered as cut-thread, commercial-ground and precision-ground respectively, the latter being divided into three optional groups according to pitch diameter limits.

We do not guarantee the size of the tapped hole.

This table does not apply to Bent Shank Tapper Taps.

Size	Threads per inch			Class		Size	Threads per inch			Class	
	NC	NF	NS	2	3		NC	NF	NS	2	3
1/4	20	..	..	Cut	CG	0	..	80	..	PG 1	PG 1
..	..	28	..	Cut	PG 2	1	64	..	..	PG 1	PG 1
5/16	18	..	..	Cut	CG	..	..	72	..	PG 1	PG 1
..	..	24	..	Cut	PG 2	..	..	..	56	PG 1	PG 1
3/8	16	..	..	Cut	CG	2	56	..	..	PG 1	PG 1
..	..	24	..	Cut	PG 2	..	..	64	..	PG 1	PG 1
7/16	14	..	..	Cut	CG	3	48	..	..	CG	PG 1
..	..	20	..	Cut	CG	..	..	56	..	CG	PG 1
1/2	13	..	..	Cut	CG	4	40	..	..	CG	PG 1
..	..	20	..	Cut	CG	..	..	48	..	CG	PG 1
9/16	12	..	..	Cut	CG	..	..	..	36	CG	PG 1
..	..	18	..	Cut	CG	5	40	..	..	CG	PG 1
5/8	11	..	..	Cut	CG	..	..	44	..	CG	PG 1
..	..	18	..	Cut	CG	6	32	..	..	CG	PG 1
11/16	..	..	11	Cut	CG	..	..	40	..	CG	PG 1
..	..	..	16	Cut	CG	8	32	..	..	CG	PG 1
3/4	10	..	..	Cut	CG	..	..	36	..	Cut or CG	PG 1
..	..	16	..	Cut	CG	10	24	..	..		PG 1
7/8	9	..	..	Cut	CG	..	..	32	..		PG 1
..	..	14	..	CG	CG	12	24	..	..		PG 1
..	..	..	18	CG	CG	..	..	28	..		PG 1
1	8	..	..	Cut	CG	14	..	..	20		PG 1
..	..	14	..	CG	CG	..	..	..	24		PG 1
1 1/8	7	..	..	Cut	CG						
..	..	12	..	CG	CG						
1 1/4	7	..	..	Cut	CG						
..	..	12	..	CG	CG						
1 3/8	6	..	..	Cut	CG						
..	..	12	..	CG	CG						
1 1/2	6	..	..	Cut	CG						
..	..	12	..	CG	CG						

SYMBOLS

CUT — Cut thread taps, either in carbon or high speed steel. See Standard Tables.
 CG — Commercial ground thread taps in high speed steel. See Standard Tables.
 PG — Precision ground thread taps.

PG 01 — Basic pitch diam. to basic minus .0005".
 PG 1 — Basic pitch diam. to basic plus .0005".
 PG 2 — Basic pitch diam. plus .0005" to basic plus .001".

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Importance of Proper Lubrication in Tapping

LONGER tap life, greater production, better size control, smoother and more accurate threads, less resharpening, also more efficient removal of chips are some of the direct results traceable to the application of proper lubricants or what are also termed cutting fluids. Unfortunately, many tap users do not appreciate the important part that proper lubricants play in tapping operations. By "Proper Lubricants" we mean lubricants of specific compositions developed for use under certain conditions on a definite requirement. In other words, there is no one lubricant or oil that can be applied to efficient and economical tapping of all requirements. Although we have given a great deal of time and study to this subject, we feel that the user of taps should take advantage of the services offered by most Oil Companies through their "Lubrication Specialists," who usually will make a survey of each customer's individual requirements and will recommend the proper lubricant for the job.

The chart on the opposite page gives suggestions and will serve as a preliminary guide until such time as the Oil Company's representative can call and make his own recommendations. In making these suggestions we, of course, have in mind production requirements and not the occasional small tapping jobs.

In addition to using the proper lubricant, some thought should be given to its method of application. To insure the utmost effectiveness it is desirable to force the lubricant into the hole under pressure. The amount of pressure applied naturally is variable and dependent upon the method of tapping, hole depth and tapping speed. However, in horizontal tapping, where the tap is stationary and the work revolves it is desirable to use two streams of lubricant, one on each side of the tap. The lubricant should enter the hole parallel to the axis of the tap where conditions permit such an arrangement. Where they do not, then at the smallest permissible angle. This will prevent the tap from running dry, and will facilitate chip removal. In any event, whether the method of tapping is vertical, horizontal or on an angle, the important point to bear in mind is to have the lubricant reach the cutting lands of the tap at all times, especially at the point or chamfered portion. Furthermore, when the lubricant is automatically applied only on the forward motion of the tap, the application of the lubricant should be timed so that it will reach the hole before the tap starts to cut. The latter applies particularly to machines on which the lubricant is automatically shut off during the tap's reversal.

The lubricant should always be at room temperature 68° F or higher, especially when used in connection with High Speed Steel Taps. High Speed Steel when cold is very brittle and will operate more efficiently when heated; consequently when the lubricant is at the suitable temperature the desired condition at which a High Speed Steel Tap operates most efficiently will be reached faster. This is especially important when starting to use a high speed tap early in the

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morning, in surroundings that have been allowed to become cold during the night.

Some consideration should also be given to the condition of the lubricant after it has been used for a certain length of time. Foreign matter such as dust, grit, etc., which contaminates the oil, is bound to get into the oil tank on most machines and this makes its replacement necessary with new clean oil; however, before replacement, the tank and piping should be thoroughly flushed to insure their cleanliness. Also the machine should be cleaned, for a great deal of the dirt which accumulates in the machine finds its way into the oil tank. Merely adding new oil as the old is used up does not eliminate the dirt from the system; therefore, a thorough cleaning at regular intervals is necessary if good tapping results are to be obtained.

Suggested Tapping Lubricants

Material being Tapped	Lubricant
Allegheny Metal	Sulphur Base Oil
Aluminum	Kerosene & Lard Oil
Bakelite	Dry
Brass	Compound or Light Base Oil
Bronze	Compound or Light Base Oil
Bronze — Manganese	Light Base Oil
Copper	Light Base Oil
Die Castings—Aluminum	Kerosene & Lard Oil
—Zinc	Compound
Duralumin.	Compound or Kerosene & Lard Oil
Fiber	Dry
Iron — Cast	Dry or Compound
— Malleable	Compound or Sulphur Base Oil
Monel Metal	Sul. Base Oil or Kerosene & Lard Oil
Nickel Silver	Sul. Base Oil or Kerosene & Lard Oil
Rubber (Hard)	Dry
Steel { Cast	Sulphur Base Oil
Chromium.	Sulphur Base Oil
Machinery	Compound or Sul. Base Oil or Kerosene & Paraffin
Manganese	Compound or Sul. Base Oil or Kerosene & Paraffin
Molybdenum	Sulphur Base Oil
Nickel	Sulphur Base Oil
Stainless	Sulphur Base Oil
Tool	Sulphur Base Oil or Kerosene & Lard Oil
Tungsten	Sulphur Base Oil
Vanadium	Sulphur Base Oil

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Tapping Speeds

PROPER speeds are essential for successful tapping. There are certain speeds at which taps operate efficiently in specific materials, but the composition of the material to be threaded, the kind of steel from which the tap is made, and the design of both the tap and tapping machine, all have a direct bearing on the tapping speeds.

The importance of proper tapping speeds cannot be stressed too strongly, for too much or insufficient speed are both detrimental to efficient tapping. A little experimentation will soon determine the right speed at which to operate. High or maximum speeds should only be reached by gradual stages of experimentation.

We show below, a table of Suggested Tapping Speeds for the most commonly used taps and materials, but, due to the many variables that enter into tapping, this table should, of course, only be used as a guide for determining speeds at which taps will operate efficiently.

Suggested Tapping Speeds

Material being Tapped	Speed in Feet per minute		
	Carbon Taps	Regular High Speed Taps	"Maxi" High Speed Taps
Allegheny Metal	*	15-25	20-30
Aluminum	45-50	90-100	100-110
Bakelite	*	60-70	70-80
Brass	45-50	90-100	100-110
Bronze	20-30	40-60	50-70
Bronze — Manganese	*	30-45	35-50
Copper	45-50	90-100	100-110
Die Castings	30-35	60-70	70-80
Duralumin	45-50	90-100	100-110
Fiber	*	80-90	90-100
Iron — Cast	*	70-80	80-90
Iron — Malleable	*	35-60	45-70
Monel Metal	*	20-25	25-30
Nickel Silver	*	75-85	85-95
Rubber (Hard)	*	80-90	90-100
Steel	Cast	*	20-30
	Chromium	*	20-30
	Machinery	20-30	40-60
	Manganese	*	10-15
	Molybdenum	*	20-30
	Nickel	*	25-35
	Stainless	*	15-25
	Tool	15-20	25-35
	Tungsten	*	20-30
	Vanadium	*	25-35

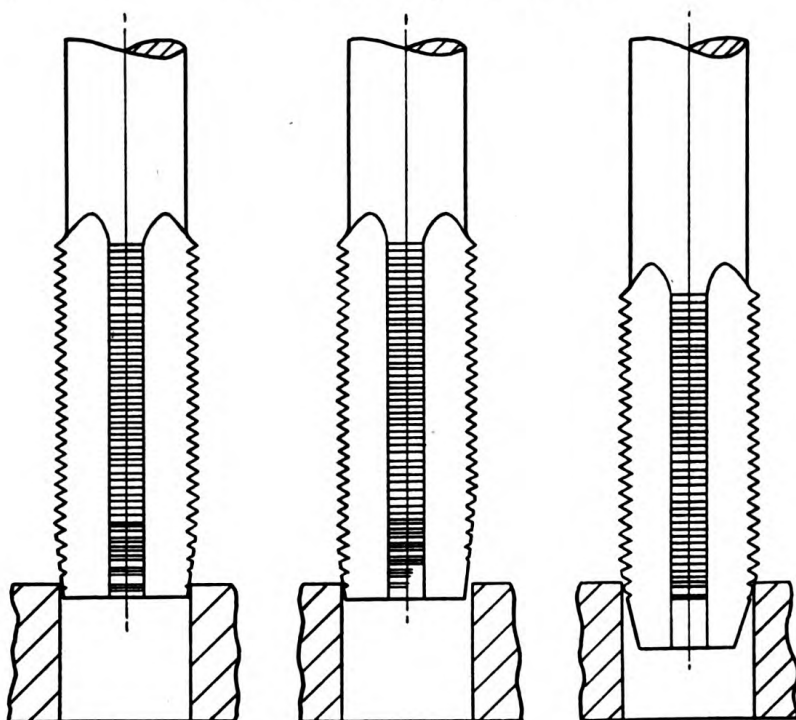
*Carbon steel taps are not recommended for these materials.

Resharpening and Grinding Taps

TAPS like all other cutting tools become dull through constant use. When dull they are liable to chip, break, produce rough and poor threads, or cut oversize. Furthermore, taps that are dull cut much harder and require more power to drive. They also frequently slow down the tapping machine. This condition can be easily remedied by resharpening. As a rule, the chamfered portion or point is the only part of the tap that requires sharpening. In many instances, this portion is re-ground by hand either on the periphery or side of the grinding wheel. This method, however, has the disadvantage of producing an uneven grind and usually results in the teeth on one or two of the lands carrying all the burden, thereby placing an excessive strain on the tap with resultant greater power consumption and undue tap breakage. Also, with the uneven grind the tap tends to cut oversize.

The sketches below show the results of both correct and incorrect chamfer grinding.

Resharpening Chamfer



Chamfer correctly ground. All lands of chamfered portion in contact. Point diameter large enough to permit only one thread to enter, thus getting full cutting benefit of practically entire chamfer.

Chamfer incorrectly ground. Lands of chamfered portion are uneven as to height, thus forcing entire cutting burden on lesser number of lands. Result — poor threads, increased power consumption, and high tap breakage.

Chamfer correctly ground as to height of lands, but point diameter too small forcing entire cutting burden on small portion of chamfered section. Result — greater power consumption, and shorter tap life due to dulling of cutting edges.

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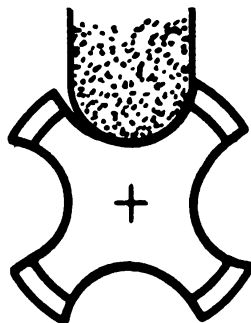
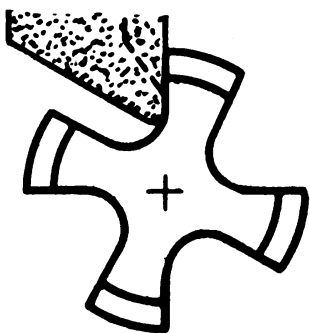
Resharpening and Grinding Taps—Continued

THE ideal way, of course, is to resharpen taps on a regular tap grinding machine. There are several such machines available, which reproduce the original grind accurately. This results in easier cutting, more accurate tapping and longer tap life.

Where a tap grinding machine is not available, and the tap must be resharpened by hand, great care should be exercised, so as to reproduce as nearly as possible the original grind of the tap manufacturer. To get best results a new tap should be used for comparison, and the operator should note carefully the number of threads chamfered, the angle, and depth of eccentric relief back of the cutting edge. A soft 80 grain grinding wheel should be used for this purpose.

The tap may also require grinding in the flutes occasionally to touch up the cutting edges of the threads or teeth. A simple method for this form of grinding is to mount the tap between centers upon a universal grinder and pass the tap back and forth under the grinding wheel. To prevent the tap from turning, the back face of the land can be held against the blade of a universal tooth rest. A hard 60 grain grinding wheel should be used and the wheel should be of the saucer or dish type when the cutting face to be ground is radial or has a straight rake. However, when the cutting face is hooked, a straight disc grinding wheel should be used and its periphery formed to suit the type of hook necessary. Forming or dressing the grinding wheel can be accomplished more accurately with a diamond, taking no deeper cuts than .001" or .002" per pass of the diamond. Sketches below show how to touch up (regrind) the cutting faces of taps.

If a universal grinder is not available, the cutting face may be ground by hand although in grinding by hand special care should be exercised to insure the tap passing under the grinding wheel, as near as possible, at right angle to the axis of the grinding wheel spindle. The original outline of the flute in the tap can be used as a guide for shaping the wheel. This also applies to the grinding of the "Gun" flute of "Gun" Taps, described in detail on page 55.

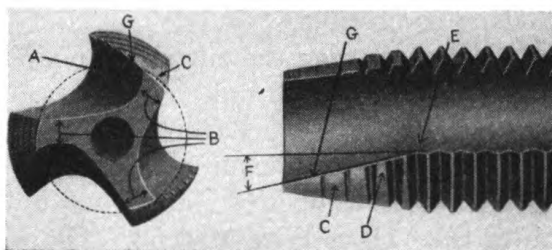


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Regardless of whether a tap is ground by hand or in a machine, only light grinding cuts should be taken to prevent the burning of the cutting edges. Polishing the ground portion after grinding is also advisable when tapping materials that have a tendency to load. Broken teeth or threads in the tap should always be completely removed, otherwise, they will damage the threads in the tapped hole. The complete elimination of broken teeth will usually have very little effect on the efficiency of the tap.

There are certain taps, however, that should always be machine ground and mechanically indexed, namely, taps relieved in the threads up to the cutting face. Such taps are Taper Pipe Taps and Special Taper Thread Taps. Machine grinding and correct indexing insure accurate spacing of the cutting faces, also uniform heights of the various lands from the axis of the tap. This type of grinding eliminates the possibility of tapping out of round holes.

Grinding the "Gun" Tap



TO MAINTAIN the "Gun" Tap at its maximum efficiency, it is necessary to bear in mind the following points in regrinding:

1. It is strongly advised that a new "Gun" Tap be used for reference, in order to maintain exactly the original form and angle of flutes and cutting edges.
2. Abrasive wheel must be dressed to fit flute, maintaining exactly form of "hook" (G).
3. When ends of lands (B) become thin from continued regrinding, grind end of tap straight back until lands again reach normal thickness. (Then reform flutes and cutting edges.) Now, refer to new "Gun" tap. Carefully reform "hook" at (G), at same time maintaining a straight cutting edge (A) and pronounced angle (F).
4. In regrinding chamfer (C) be sure to grind the relief, leaving cutting edge (A) the highest edge — gradually backing away towards heel, shown by circle at (C) in cut at left above.
5. Maintain angle (F) for shear cut.
6. In regrinding, remove only enough metal to keep cutting edges sharp, at same time retaining original form of flutes.

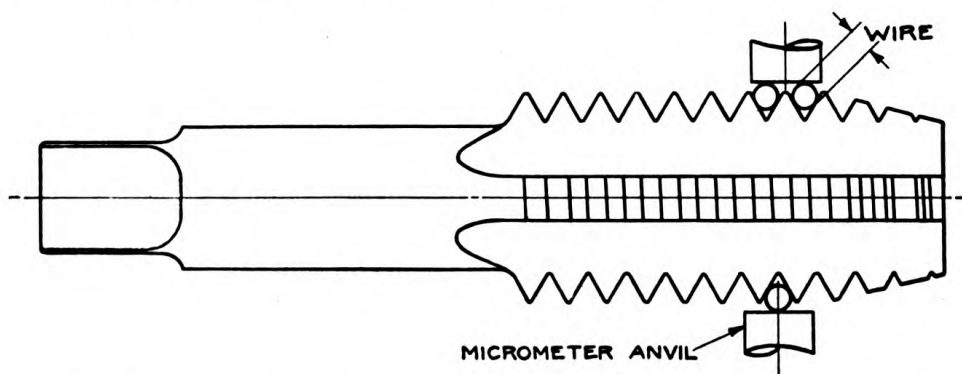
Measuring Taps

THERE are two important size measurements on a tap, namely, outside diameter and pitch diameter of the threaded portion. Like any other cutting tool wear will eventually take place on the tap; therefore, occasional checking of the tap size is quite important in certain tapping operations, particularly if the size of the tapped hole is to be maintained within certain limits. When such measurements are taken, however, two factors in the design of taps should be taken into consideration, namely *back taper* and *thread relief*.

Back taper is a gradual decrease in the thread diameter towards the shank. This is usually about .001" in the diameter per one inch of length. *Thread relief* gradually decreases the thread diameter towards the heel of the land and as a rule covers about two thirds of the land width although in certain cases it may cover the entire width. The function of *back taper* and *thread relief* is to provide easier cutting action and all taps are constructed in this manner with the exception of some of the smaller sizes which have *back taper* only; therefore, measurements for size should always be taken immediately behind the chamfer and as near to the cutting face of the land as possible.

A very simple method for measuring the outside or major diameter of a tap is by means of a micrometer caliper (plain mike). For measuring the pitch diameter of a tap, a Thread Micrometer Caliper (thread mike) can be used.

A more accurate measurement of the pitch diameter, however, can be obtained by means of a micrometer caliper or similar instrument and three measuring wires. This is called the "Three Wire Method." The wires are placed in the threads of the tap and the measurements are taken over the wires with the micrometer caliper. Cut below illustrates this latter method.



The National Form 60° Thread is the standard for the United States and the "best size" wires for this form of thread are standard and are available for immediate shipment from stock. When measuring other forms of thread the nearest National Form 60° "best size" wire is generally used so that the necessity for keeping a much larger inventory of special sizes of wires is eliminated.

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When taking these measurements, it should be borne in mind that all taps are made slightly larger than their basic dimensions in order to allow for wear. The manufacturing tolerances to which taps are made will be found in the tables in the back of this book.

The table on page 59 greatly simplifies the conversion of a 60° thread pitch diameter measurement to a "Three Wire Measurement" and vice versa. The "Best Size" wire is taken as that size wire which will touch the flanks of the thread groove at the point where the space equals one half of the pitch; in other words, the contact is at the same point as the pitch diameter, thus eliminating errors that might be caused by inaccurate angles of the thread groove.

A similar table for 29° Acme threads is also shown on this same page.

The "best size" wire diameter can be found by use of the formula:

$$\text{"Best size" wire diameter} = \frac{1}{2} \text{ pitch} \times (\secant \text{ of } \frac{1}{2} \text{ thread angle})$$

or

$$\text{"Best size" wire diameter} = \frac{\secant \text{ of } \frac{1}{2} \text{ thread angle}}{2 \times \text{No. threads per inch}}$$

Tables of Tangents, Cotangents, Cosines, Secants and Cosecants of angles are common in many shop handbooks.

$$\text{For } 60^\circ \text{ threads the secant of } \frac{1}{2} \text{ of } 60^\circ \text{ or } 30^\circ = 1.15470$$

$$\text{then the "best size" wire for } 60^\circ \text{ threads} = \frac{1.15470}{2 \times \text{No. threads per inch}}$$

For Acme Threads:

$$\text{The "best size" wire for } 29^\circ \text{ threads} = \frac{1.03290}{2 \times \text{No. threads per inch}}$$

Other sizes of wires can be used to measure external threads provided the wires are not so large as to contact the corners at the crest of the thread, or so small as to give a measurement over the wires less than the outside diameter of screw being measured. However, wires close to the "best size" give the most accurate results.

The wires should be glass hard cylinders of steel accurately finished, round within .00002 and straight within .00002 over any quarter inch interval. The three wires should have the same diameter within .00003 and this common diameter should be within .0001 of the "best size" for the pitch on which it is to be used. Any error in the wires is multiplied several times in making the measurement.

Great care must be used not to apply too much pressure in making the measurement over the wires. For pitches finer than 20 threads per inch, a pressure of 14 to 16 ounces is recommended. For pitches of 20 threads per inch and coarser, a pressure from 2¼ to 2½ pounds is recommended.

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Measuring Taps—Continued

The general formula for finding the pitch diameter of any thread with symmetrical angular sides is as follows:

$$\text{P.D.} = \text{Measurement} + \frac{\text{cotangent } \frac{1}{2} \text{ angle}}{2 \times \text{No. thds. per inch}} - W \times (1 + \text{cosecant } \frac{1}{2} \text{ angle}) - W \times \frac{(\text{tangent helix angle})^2 \times \text{cosine } \frac{1}{2} \text{ angle} \times \text{cotangent } \frac{1}{2} \text{ angle}}{2}$$

Formula for the tangent of helix angle:

$$\text{Tangent helix angle} = \frac{\text{Lead}}{3.1416 \times \text{P.D.}}$$

The following term in the formula determines the correction for helix angle.

$$W \times \frac{(\text{tangent helix angle})^2 \times \text{cosine } \frac{1}{2} \text{ angle} \times \text{cotangent } \frac{1}{2} \text{ angle}}{2}$$

Unless this correction amounts to more than .00015 the whole term is omitted, making a simplified formula as follows:

$$\text{P.D.} = \text{Measurement} + \frac{\text{cotangent } \frac{1}{2} \text{ angle}}{2 \times \text{No. thds. per inch}} - W \times (1 + \text{cosecant } \frac{1}{2} \text{ angle})$$

This formula is used when the P.D. is to be determined.

The following is a rearrangement to give the "Measurement" when the P.D. is known:

$$\text{Measurement} = \text{P.D.} - \frac{\text{cotangent } \frac{1}{2} \text{ angle}}{2 \times \text{No. thds. per inch}} + W \times (1 + \text{cosecant } \frac{1}{2} \text{ angle})$$

In measuring most standard screws the simplified formula is used. The following formulae give these two arrangements for the more common styles of thread forms:

Formulae for calculating the "measurement" when the P.D. is known.

National Form 60° Thread: Measurement = P.D. + (3 W - .86602 P)

Whitworth Form 55° Thread: Measurement = P.D. + (3.1657 W - .96049 P)

British Association Form 47½° Thread:

$$\text{Measurement} = \text{P.D.} + (3.4829 W - 1.13633 P)$$

Loewenherz Form 53° 8' Thread: Measurement = P.D. + (3.2359 W - P)

Acme Form 29° Thread: Measurement = P.D. + (4.9939 W - 1.93334 P)

Formulae for calculating the P.D. when the Measurement is available.

National Form 60° Thread P.D. = Measurement - (3 W - .86602 P)

Whitworth Form 55° Thread P.D. = Measurement - (3.1657 W - .96049 P)

British Association Form 47½° Thread:

$$\text{P.D.} = \text{Measurement} - (3.4829 W - 1.13633 P)$$

Loewenherz Form 53° 8' Thread: P.D. = Measurement - (3.2359 W - P)

Acme Form 29° Thread P.D. = Measurement - (4.9939 W - 1.93334 P)

On Page 59 are tables that give the constants for that part of the formulae included in parentheses for the National Form 60° Thread (3 W - .86602 P) and for the Acme Form 29° Thread (4.9939 W - 1.93334 P).

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Converting 3 Wire Measurement to 60° Thread Pitch Diameter

P. D. = Measurement - Constant
Constant = (3 W - .86602 P)

Measurement = P. D. + Constant
* Indicates "Best Size" Wire

T. P. I.	Wire (W)	Constant	Wire (W)	Constant	Wire (W)	Constant
3	.1924498*	.288674	.....	.266469	.....	.....
3 1/4	.1924498	.310880	.1776462*	.285506	.1649572*	.247435
3 1/2	.1924498	.329917	.1776462	.316432	.1649572	.278365
4	.1443375*	.216509	.1776462	.192449	.1649572	.302421
4 1/4	.1443375	.240566	.1282998*	.211694	.1154700*	.173205
5	.1443375	.259811	.1282998	.227440	.1154700	.188951
5 1/4	.1049727*	.157459	.1282998	.144338	.1154700	.202073
6	.1049727	.170581	.0962250*	.164957	.0824786*	.123718
7	.1049727	.191200	.0962250	.180421	.0824786	.139182
8	.0721687*	.108253	.0962250	.096225	.0824786	.151210
9	.0721687	.120281	.0641500*	.105847	.0577350*	.086602
10	.0721687	.129903	.0641500	.113720	.0577350	.094475
11	.0524863*	.087829	.0641500	.075306	.0577350	.097898
11 1/4	.0524863	.082152	.0502043*	.078444	.0481125*	.072169
12	.0524863	.085290	.0502043	.083995	.0481125	.077720
13	.0444115*	.066617	.0502043	.061859	.0481125	.082479
14	.0444115	.071376	.0412393*	.069591	.0360841*	.054125
16	.0444115	.079108	.0412393	.075605	.0360841	.060140
18	.0320741*	.048110	.0412393	.045579	.0360841	.062672
19	.0320741	.050642	.0303865*	.047858	.0288675*	.043301
20	.0320741	.052921	.0303865	.051795	.0288675	.047238
22	.0262431*	.039365	.0303865	.036082	.0288675	.050518
24	.0262431	.042645	.0240553*	.038857	.0222054*	.033308
26	.0262431	.045421	.0240553	.040092	.0222054	.034541
27	.0213833*	.032075	.0240553	.030929	.0222054	.035687
28	.0213833	.033220	.0206194*	.032991	.0192448*	.028867
30	.0213833	.035282	.0206194	.034795	.0192448	.030671
32	.0180421*	.027063	.0206194	.025471	.0192448	.032263
34	.0180421	.028655	.0169808*	.026885	.0160370*	.024055
36	.0180421	.030070	.0169808	.029290	.0160370	.026460
40	.0144337*	.021650	.0169808	.019682	.0160370	.028428
44	.0144337	.023619	.0131214*	.021322	.0120279*	.018041
48	.0144337	.025259	.0131214	.022043	.0120279	.018763
50	.0115470*	.017320	.0131214	.015464	.0120279	.020619
56	.0115470	.019176	.0103097*	.017397	.0090210*	.013531
64	.0115470	.021109	.0103097	.018901	.0090210	.015035
72	.0080184*	.012027	.0103097	.010825	.0090210	.016237
80	.0080184	.013229	.0072168*			

Converting 3 Wire Measurement to 29° Thread Pitch Diameter

P. D. = Measurement - Constant
Constant = (4.9939 W - 1.9333 P)

Measurement = P. D. + Constant
† Indicates nearest to "Best Size" Wire.

* Indicates "Best Size" Wire.

† Indicates nearest to "Best Size" Wire.

T. P. I.	Wire (W)	Constant	Wire (W)	Constant
1	.516440*	.64565	.....	.....
1 1/4	.344293*	.43058	.....	.....
2	.258220*	.32282	.....	.....
2 1/4	.206576*	.25826	.....	.....
3	.1776462†	.24268	.....	.....
3 1/4	.1443375†	.16842	.....	.....
4	.1443375	.23746	.1282998†	.15736
4 1/4	.1154700†	.14728	.1282998	.21134
5	.1154700	.18997	.1049727†	.13755
5 1/4	.0962250†	.12901	.1049727	.17269
6	.0962250	.15832	.0824786†	.08967
7	.0721687†	.08422	.0824786	.13570
7 1/4	.0721687†	.10262	.0824786	.15411
8	.0721687	.11872	.0641500†	.07868
9	.0577350†	.07350	.0641500	.10554
10	.0577350	.09498	.0524863†	.06877
12	.0444115†	.06067	.0524863	.10099

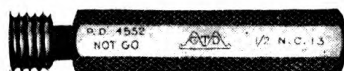
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Measuring Tapped Holes

THE general practice of measuring tapped holes is by means of Thread Limit Plug Gages. "Greenfield" manufactures gages which conform to the American Gage Design Standards, usually to Class 2 or 3 limits and tolerances as specified in the National Screw Thread Commission's last report, revised in 1933.



Style No. 1502



Style No. 1551

Single End



Style No. 1520 Double End

The set of two gages shown at top consists of a "Go," and a "Not Go" Gage, each mounted in a separate handle. Lower set shows the double ended type with a "Go" member mounted in one end of the handle and a "Not Go" in the other. Both types are intended for the same purpose, but the double ended type being one unit is more convenient to use.

The "Go" end is always longer than the "Not Go" end, therefore easily identified. In addition to controlling size of the tapped hole, they also check lead and angle error of the threads in the hole. The accepted practice when gaging a tapped hole, is to have the "Go" gage enter the full length and the "Not Go" gage not enter more than $1\frac{1}{2}$ turns, the "Go" gage pitch diameter being made to the minimum dimension, usually basic, and the "Not Go" to the maximum.

Occasionally, when a tap has become worn and dull, the tapped hole will still permit the "Go" gage to enter, though tight, and the natural assumption is that the "Not Go" cannot enter on account of having a larger pitch diameter. However, if the "Not Go" gage does enter, the question arises as to the cause of this condition. The answer is that the "Go" gage is contacting on the major or outside diameter only, whereas the "Not Go" gage having a truncated major diameter clears the major diameter of the tapped hole and contacts the flanks of the threads. This shows up the lead or angle errors sometimes caused by worn and dull taps. It is for this reason that, while the major diameter of a "Go" plug gage of any "National" screw thread has a basic flat at the crest, of $\frac{1}{8}$ times the pitch, the "Not Go" is truncated to approximately $\frac{1}{4}$ times the pitch. This same condition can also arise when the major diameter of the tap has worn down to a point where the "Go" gage will not enter, yet the "Not Go" will. The latter condition happens more frequently than the former because as a rule the greatest wear on a tap is at the major diameter.

On Pages 118-119 are comparative charts showing Pitch Diameter Gaging Limits for Classes 1, 2, 3 and 4 fits.

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Trouble Sources in Tapping

THE various steps incidental to good tapping have already been considered, and, as a guide for locating the source of tapping troubles which may be encountered, we suggest checking the points listed below. Remedies should be applied as suggested by the proper procedures described in the preceding pages. The following checking points are listed in the order and under the headings followed in the text.

Type of Machine

- Was tap started correctly?
- Is drive uneven because of slipping belts?
- Is machine powered properly?
- Are tap and drilled hole in alignment?
- Is there undue wear on sliding parts?

Tap Holding Device

- Is worn or wrong type of holder being used?
- Is holder in alignment with drilled hole?

Type of Holes to be Tapped

- If a blind hole, is there sufficient untapped space at the bottom for the accumulation of chips?
- Is a "Gun" tap that shoots the chips ahead being used? (In a blind hole tapped very nearly to the bottom and having no recess, the "Gun" tap is not recommended.)
- Does condition call for a two or three fluted tap?

Class of Fit Required

- If the tap produces an oversize hole, has the proper tap been selected for the class of fit desired? (See table on Page 49.)
- If proper tap is being used, is there any play in the work or tap holding spindles?
- Do the work and tap line up accurately?
- Is the tap dull? (See Pages 53-55 for proper resharpener.)

Tapping Different Materials

- Has the tap the proper cutting face for the particular material being tapped?
- Is the tap of the proper design or type?

Proper Hole Sizes before Tapping

- Is the drilled hole of the proper size?
- Is the drilled hole perfectly round?
- Is the axis of the hole parallel to the axis of the tap?

Lubrication

- Has the proper lubricant been employed?
- Does the lubricant flood the tap sufficiently while engaged in the hole?
- Is there sufficient force behind the lubricant to wash away the chips?
- If applied with a brush has the lubricant a sufficiently heavy body to adhere to the tap? (A light lubricant will be thrown off the revolving tap before it enters the hole.)



Trouble Sources in Tapping — *Continued*

Tapping Speeds

Is the speed too slow?

Is the speed too fast?

Chamfer (Resharpening and Grinding)

Is the point diameter correct for the size of hole being tapped? Or does the tap enter the hole for a distance of several threads before taking hold, thereby losing the full benefit of the entire chamfered portion? (See page 53 for correct chamfering practice.)

Is the chamfer the correct length?

Is the chamfer chipped or dull and in need of regrinding?

Is the chamfer relief too great or not sufficient?

Things to Remember When Ordering Special Taps

IN ORDERING special taps where the chances of making errors are greater than in the case of regular taps, it is always well to remember to furnish, whenever possible, blueprints or sketches giving detailed specifications of the taps desired, or samples of the tools to be duplicated. In the absence of blueprints or samples, the following information should be furnished.

1. Exact cutting size, number of threads per inch, and form of thread. (If Multiple Thread, whether Double, Triple, etc., wanted.)
2. Whether right or left hand thread wanted.
3. Style of tap wanted, that is, Taper, Plug or Bottoming Hand Tap, Gun Tap, Nut Tap, Tapper Tap, Pulley Tap, etc.
4. Whether High Speed or Carbon Taps are wanted.
5. Whether taps are to be furnished with cut or ground threads.
6. If ground thread taps are wanted, class of fit taps are to produce.
7. Overall length; thread length; and length, style, and diameter of shank wanted.
8. Number of flutes, if not standard, and whether flutes are to be straight, spiral or gun.
9. If spiral flutes are wanted, whether they are to be right or left hand spiral.
10. Length of thread to be cut.
11. Whether taps are to be used in through or blind holes.
12. Size of hole before tapping, and depth of hole to be tapped.
13. Kind of material to be threaded.
14. Are taps to be used by hand or in a machine? If machine, advise type.

When all these details are given, they not only insure our making up the kind of taps wanted, but enable us to furnish taps which are best suited for the work to be performed.

Part III

TABLES SHOWING TAP DIMENSIONS AND TOLERANCES, THREAD FORMS, ETC.

THIS section is made up entirely of charts and tables. The information shown in the tables of dimensions and tolerances to which various types of taps are manufactured, will be of interest to those who may wish to know more about technical aspects of tap manufacture.

The many tables of decimal equivalents, tap drill sizes, thread forms, and similar valuable data will also prove of inestimable assistance to users of taps, on numerous occasions.

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TABLE 301
Standard System of Marking

1. General

Manufacturers of small tools recognizing the necessity of a standard system of marking taps, dies and other threading tools will mark their tools with the nominal size, number of threads per inch, and the proper symbol to identify the thread form.

Symbols commonly used in American practice are:

NC,	indicating American National Coarse Thread Series.
NF,	indicating American National Fine Thread Series.
N,	indicating American National 8, 12 and 16 pitch Series.
NS,	indicating American National Special Thread Series.
NH,	indicating American National Hose Coupling Threads.
NPT,	indicating American National Taper Pipe Threads.
NPS,	indicating American National Straight Pipe Threads.
GREASE,	indicating a standardized undersize straight pipe thread for grease cup fittings.
STEAM,	indicating a straight pipe thread used on coupling taps.
CONDUIT,	indicating an oversize straight pipe thread used on coupling taps.
V,	indicating a 60 degree V thread usually with both the crest and root flattened several thousandths from the theoretical to the user's specifications.
ACME,	indicating a standardized 29 degree thread.
SB,	indicating manufacturers stove bolt standard thread.

Such markings as USS, USF, SAE, and ASME are now obsolete.

2. Bent Shank Tapper Taps.

In addition to the regular marking bent shank tapper taps when made to Table No. 336 are marked "Class 2." When made to Table No. 337 are marked "Class 3."

3. Special Taps.

Special taps (except ground thread taps marked with a limit number as specified in section No. 4) varying only slightly from standard dimensions are to be marked with the letter "S" enclosed in a circle ©.

Taps varying on the pitch diameter up to .015" over or under basic will be marked with the actual amount the low limit is over or under basic size, in addition to the standard size.

Left hand taps will be marked "Left Hand" or "LH" in addition to the standard marking.

4. Ground Thread Taps

All commercial ground thread taps made to the thread limits shown in Tables No. 326 and No. 329, will be marked with one ring on the shank near the thread in addition to the standard marking.

All precision ground thread taps made to the thread limits shown in Table No. 327 will be marked with the limit number. Other precision ground thread taps will be marked with the same limit number, as follows:

Taps having a pitch diameter between basic and minus .0005" . . .	01
Taps having a pitch diameter between basic and plus .0005" . . .	1
Taps having a pitch diameter between .0005" to .0010" over basic	2

(Concluded on following page)

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TABLE 301
Standard System of Marking
(Concluded)

Ground thread pipe taps made to Tables No. 335 and No. 338 will be marked "CG."

Other special ground thread taps will be marked "CG" if the pitch diameter grinding tolerance is equal to or greater than shown below, and will be marked "PG" if it is less.

4 to 5½ threads per inch inclusive .....	.0020"
6 threads per inch .....	.0018"
7 threads per inch .....	.0015"
8 threads per inch .....	.0014"
9 threads per inch .....	.0012"
10 and 11½ threads per inch .....	.0011"
12 threads per inch and finer .....	.0010"

5. Multiple Thread Taps and Dies.

Taps and dies having multiple thread will be marked with diameter, number of threads to the inch, form of thread and lead designated in fractions; also double, triple or quadruple.

For example: A 1"—16 double thread special tap with National form of thread will be marked as follows:

1"—16 N. S. ⅛" Lead Double

The same tap with Acme thread will be marked as follows:

1"—16 Acme ⅛" Lead Double

6. American National Thread Series.

The sizes and pitches included in the American National Coarse Thread Series are as follows:

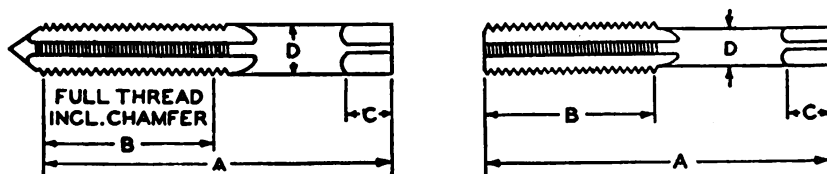
No. 1—64	No. 12—24	¾"—10	2"—4½
No. 2—56	¼"—20	⅞"—9	2¼"—4½
No. 3—48	⅝"—18	1"—8	2½"—4
No. 4—40	⅜"—16	1⅛"—7	2¾"—4
No. 5—40	⅞"—14	1¼"—7	3"—4
No. 6—32	½"—13	1⅜"—6	3¼"—4
No. 8—32	⅑"—12	1½"—6	3½"—4
No. 10—24	⅝"—11	1¾"—5	3¾"—4
			4"—4

The sizes and pitches included in the American National Fine Thread Series are as follows:

No. 0—80	No. 6—40	⅜"—24	⅞"—14
No. 1—72	No. 8—36	⅞"—20	1"—14
No. 2—64	No. 10—32	1"—20	1⅛"—12
No. 3—56	No. 12—28	⅑"—18	1¼"—12
No. 4—48	¼"—28	⅝"—18	1⅝"—12
No. 5—44	⅝"—24	¾"—16	1½"—12

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TABLE 302
Hand Taps



GENERAL DIMENSIONS

Diameter of Tap Inches	Dimensions—Inches				
	Length Overall A	Length of Full Thread B	Length of Square C	Diameter of Shank D	Size of Square E
$\frac{1}{16}$	$1 \frac{5}{8}$	$\frac{5}{16}$	$\frac{3}{16}$	.141	.110
$\frac{3}{32}$	$1 \frac{3}{4}$	$\frac{7}{16}$	$\frac{3}{16}$	.141	.110
$\frac{1}{8}$	$1 \frac{15}{16}$	$\frac{5}{8}$	$\frac{3}{16}$	.141	.110
$\frac{5}{32}$	$2 \frac{1}{16}$	$\frac{3}{4}$	$\frac{1}{4}$	.160	.125
$\frac{3}{16}$	$2 \frac{3}{8}$	$\frac{7}{8}$	$\frac{1}{4}$	.192	.149
$\frac{7}{32}$	$2 \frac{3}{8}$	$1 \frac{5}{16}$	$\frac{1}{4}$	.223	.167
$\frac{1}{4}$	$2 \frac{1}{2}$	1	$\frac{9}{32}$	.255	.191
$\frac{9}{32}$	$2 \frac{1}{2}$	1	$\frac{5}{16}$	.286	.214
$\frac{5}{16}$	$2 \frac{23}{32}$	$1 \frac{1}{8}$	$\frac{5}{16}$	.318	.238
$\frac{11}{32}$	$2 \frac{23}{32}$	$1 \frac{1}{8}$	$\frac{11}{32}$	.349	.262
$\frac{3}{8}$	$2 \frac{15}{16}$	$1 \frac{1}{4}$	$\frac{3}{8}$	.381	.286
$\frac{13}{32}$	$3 \frac{5}{32}$	$1 \frac{7}{16}$	$\frac{13}{32}$	.323	.242
$\frac{7}{16}$	$3 \frac{5}{32}$	$1 \frac{7}{16}$	$\frac{13}{32}$	.323	.242
$\frac{15}{32}$	$3 \frac{5}{32}$	$1 \frac{7}{16}$	$\frac{13}{32}$	.354	.265
$\frac{1}{2}$	$3 \frac{3}{8}$	$1 \frac{21}{32}$	$\frac{7}{16}$	.367	.275
$\frac{17}{32}$	$3 \frac{3}{8}$	$1 \frac{21}{32}$	$\frac{7}{16}$	.398	.298
$\frac{9}{16}$	$3 \frac{19}{32}$	$1 \frac{21}{32}$	$\frac{1}{2}$	.429	.322
$\frac{19}{32}$	$3 \frac{19}{32}$	$1 \frac{21}{32}$	$\frac{1}{2}$	.460	.345
$\frac{5}{8}$	$3 \frac{13}{16}$	$1 \frac{13}{16}$	$\frac{9}{16}$	.480	.360
$\frac{21}{32}$	$3 \frac{13}{16}$	$1 \frac{13}{16}$	$\frac{9}{16}$	.511	.383
$\frac{11}{16}$	$4 \frac{1}{32}$	$1 \frac{13}{16}$	$\frac{5}{8}$	.542	.406
$\frac{23}{32}$	$4 \frac{1}{32}$	$1 \frac{13}{16}$	$\frac{5}{8}$	.573	.430
$\frac{3}{4}$	$4 \frac{1}{4}$	2	$\frac{11}{16}$	.590	.442
$\frac{25}{32}$	$4 \frac{1}{4}$	2	$\frac{11}{16}$	.621	.466
$\frac{13}{16}$	$4 \frac{15}{32}$	2	$\frac{11}{16}$	.652	.489
$\frac{27}{32}$	$4 \frac{15}{32}$	2	$\frac{11}{16}$	.684	.513
$\frac{7}{8}$	$4 \frac{11}{16}$	$2 \frac{7}{32}$	$\frac{3}{4}$	.697	.523
$\frac{15}{16}$	$4 \frac{29}{32}$	$2 \frac{7}{32}$	$\frac{3}{4}$	.760	.570
1	5 $\frac{1}{8}$	$2 \frac{1}{2}$	$\frac{13}{16}$	.800	.600
$1 \frac{1}{16}$	5 $\frac{1}{8}$	$2 \frac{1}{2}$	$\frac{13}{16}$.862	.646
$1 \frac{1}{8}$	5 $\frac{7}{16}$	$2 \frac{9}{16}$	$\frac{7}{8}$.896	.672

(Continued on following page)

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TABLE 302

(Continued)

Hand Taps

GENERAL DIMENSIONS

Diameter of Tap Inches	Dimensions—Inches				
	Length Overall A	Length of Full Thread B	Length of Square C	Diameter of Shank D	Size of Square E
1 $\frac{3}{16}$	5 $\frac{7}{16}$	2 $\frac{9}{16}$	$\frac{7}{8}$	.959	.719
1 $\frac{1}{4}$	5 $\frac{3}{4}$	2 $\frac{9}{16}$	1	1.021	.766
1 $\frac{5}{16}$	5 $\frac{3}{4}$	2 $\frac{9}{16}$	1	1.084	.813
1 $\frac{3}{8}$	6 $\frac{1}{16}$	3	1 $\frac{1}{16}$	1.108	.831
1 $\frac{7}{16}$	6 $\frac{1}{16}$	3	1 $\frac{1}{16}$	1.171	.878
1 $\frac{1}{2}$	6 $\frac{3}{8}$	3	1 $\frac{1}{8}$	1.233	.925
1 $\frac{5}{8}$	6 $\frac{11}{16}$	3 $\frac{3}{16}$	1 $\frac{1}{8}$	1.305	.979
1 $\frac{3}{4}$	7	3 $\frac{3}{16}$	1 $\frac{1}{4}$	1.430	1.072
1 $\frac{7}{8}$	7 $\frac{5}{16}$	3 $\frac{9}{16}$	1 $\frac{1}{4}$	1.519	1.139
2	7 $\frac{5}{8}$	3 $\frac{9}{16}$	1 $\frac{3}{8}$	1.644	1.233
2 $\frac{1}{8}$	8	3 $\frac{9}{16}$	1 $\frac{3}{8}$	1.769	1.327
2 $\frac{1}{4}$	8 $\frac{1}{4}$	3 $\frac{9}{16}$	1 $\frac{7}{16}$	1.894	1.420
2 $\frac{3}{8}$	8 $\frac{1}{2}$	4	1 $\frac{7}{16}$	2.019	1.514
2 $\frac{1}{2}$	8 $\frac{3}{4}$	4	1 $\frac{1}{2}$	2.100	1.575
2 $\frac{5}{8}$	8 $\frac{3}{4}$	4	1 $\frac{1}{2}$	2.225	1.669
2 $\frac{3}{4}$	9 $\frac{1}{4}$	4	1 $\frac{9}{16}$	2.350	1.762
2 $\frac{7}{8}$	9 $\frac{1}{4}$	4	1 $\frac{9}{16}$	2.475	1.856
3	9 $\frac{3}{4}$	4 $\frac{9}{16}$	1 $\frac{5}{8}$	2.543	1.907
3 $\frac{1}{8}$	9 $\frac{3}{4}$	4 $\frac{9}{16}$	1 $\frac{5}{8}$	2.668	2.001
3 $\frac{1}{4}$	10	4 $\frac{9}{16}$	1 $\frac{3}{4}$	2.793	2.095
3 $\frac{3}{8}$	10	4 $\frac{9}{16}$	1 $\frac{3}{4}$	2.883	2.162
3 $\frac{1}{2}$	10 $\frac{1}{4}$	4 $\frac{15}{16}$	2	3.008	2.256
3 $\frac{5}{8}$	10 $\frac{1}{4}$	4 $\frac{15}{16}$	2	3.133	2.350
3 $\frac{3}{4}$	10 $\frac{1}{2}$	5 $\frac{5}{16}$	2 $\frac{1}{8}$	3.217	2.413
3 $\frac{7}{8}$	10 $\frac{1}{2}$	5 $\frac{5}{16}$	2 $\frac{1}{8}$	3.342	2.506
4	10 $\frac{3}{4}$	5 $\frac{5}{16}$	2 $\frac{1}{4}$	3.467	2.600

SPECIAL TAPS

UNLESS otherwise specified:

Fine pitch hand taps 1 $\frac{1}{8}$ " diameter and larger will be made to Table 303.

Use Table 304 for special hand taps under $\frac{1}{4}$ " diameter whose nominal diameter is not listed in this table.

All special hand taps $\frac{1}{4}$ " diameter and over, whose nominal diameter is more than .010" over the diameter of any size listed in this table, will be furnished with the length, shank and square dimensions of the next larger size tap.

Special cut and ground thread taps will be made to limits shown in Tables 330 and 331.

(Concluded on following page)

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TABLE 302
(Concluded)

Hand Taps

TOLERANCES

Element	Range Inches	Direction	Tolerance	
			Cut Thread Inches	Ground Thread Inches
Length Overall—A	$\left\{ \begin{array}{l} \frac{1}{16} \text{ to } 1 \text{ incl.} \\ 1 \frac{1}{16} \text{ to } 4 \text{ incl.} \end{array} \right.$	$\left\{ \begin{array}{l} \text{Plus or Minus} \\ \text{Plus or Minus} \end{array} \right.$	$\left\{ \begin{array}{l} \frac{1}{32} \\ \frac{1}{16} \end{array} \right.$	$\left\{ \begin{array}{l} \frac{1}{32} \\ \frac{1}{16} \end{array} \right.$
Length of Thread—B	$\left\{ \begin{array}{l} \frac{1}{16} \text{ to } \frac{7}{32} \text{ incl.} \\ \frac{1}{4} \text{ to } \frac{1}{2} \text{ incl.} \\ \frac{9}{16} \text{ to } 1 \frac{1}{2} \text{ incl.} \\ 1 \frac{5}{8} \text{ to } 4 \text{ incl.} \end{array} \right.$	$\left\{ \begin{array}{l} \text{Plus or Minus} \\ \text{Plus or Minus} \\ \text{Plus or Minus} \\ \text{Plus or Minus} \end{array} \right.$	$\left\{ \begin{array}{l} \frac{3}{64} \\ \frac{1}{16} \\ \frac{3}{32} \\ \frac{1}{8} \end{array} \right.$	$\left\{ \begin{array}{l} \frac{3}{64} \\ \frac{1}{16} \\ \frac{3}{32} \\ \frac{1}{8} \end{array} \right.$
Length of Square—C	$\left\{ \begin{array}{l} \frac{1}{16} \text{ to } 1 \text{ incl.} \\ 1 \frac{1}{16} \text{ to } 4 \text{ incl.} \end{array} \right.$	$\left\{ \begin{array}{l} \text{Plus or Minus} \\ \text{Plus or Minus} \end{array} \right.$	$\left\{ \begin{array}{l} \frac{1}{32} \\ \frac{1}{16} \end{array} \right.$	$\left\{ \begin{array}{l} \frac{1}{32} \\ \frac{1}{16} \end{array} \right.$
Diameter of Shank—D	$\left\{ \begin{array}{l} \frac{1}{16} \text{ to } \frac{7}{32} \text{ incl.} \\ \frac{1}{4} \text{ to } \frac{5}{8} \text{ incl.} \\ \frac{11}{16} \text{ to } 1 \text{ incl.} \end{array} \right.$	$\left\{ \begin{array}{l} \text{Minus} \\ \text{Minus} \\ \text{Minus} \end{array} \right.$	$\left\{ \begin{array}{l} .004 \\ .005 \\ .005 \end{array} \right.$	$\left\{ \begin{array}{l} .0015 \\ .0015 \\ .002 \end{array} \right.$
	$\left\{ \begin{array}{l} 1 \frac{1}{16} \text{ to } 1 \frac{1}{2} \text{ incl.} \\ 1 \frac{5}{8} \text{ to } 2 \text{ incl.} \\ 2 \frac{1}{8} \text{ to } 4 \text{ incl.} \end{array} \right.$	$\left\{ \begin{array}{l} \text{Minus} \\ \text{Minus} \\ \text{Minus} \end{array} \right.$	$\left\{ \begin{array}{l} .007 \\ .007 \\ .009 \end{array} \right.$	$\left\{ \begin{array}{l} .002 \\ .003 \\ .003 \end{array} \right.$
	$\left\{ \begin{array}{l} \frac{1}{16} \text{ to } \frac{1}{2} \text{ incl.} \\ \frac{9}{16} \text{ to } 1 \text{ incl.} \\ 1 \frac{1}{16} \text{ to } 2 \text{ incl.} \\ 2 \frac{1}{8} \text{ to } 4 \text{ incl.} \end{array} \right.$	$\left\{ \begin{array}{l} \text{Minus} \\ \text{Minus} \\ \text{Minus} \\ \text{Minus} \end{array} \right.$	$\left\{ \begin{array}{l} .004 \\ .006 \\ .008 \\ .010 \end{array} \right.$	$\left\{ \begin{array}{l} .004 \\ .006 \\ .008 \\ .010 \end{array} \right.$
Size of Square—E				

FORMULAE—(Approximate)

Diameter of Shank	Large Shanks	$\left\{ \begin{array}{l} \frac{1}{16}'' \text{ to } \frac{1}{8}'' \text{ Incl.} \\ \frac{3}{32}'' \text{ and Larger} \end{array} \right.$	$\left\{ \begin{array}{l} = \text{Diameter of Shank of } \frac{1}{8}'' \text{ Tap.} \\ = \text{Approximate Maximum Major Diameter.} \end{array} \right.$
	Small Shanks		= Basic Major Diameter—(Std. V Pitch x 1.6 to nearest .001").
Size of Square		$\left\{ \begin{array}{l} \frac{1}{16}'' \text{ to } \frac{3}{16}'' \\ \frac{1}{32}'' \text{ and Larger} \end{array} \right.$	$\left\{ \begin{array}{l} = \text{Diameter of Shank x .78 to nearest .001".} \\ = \text{Diameter of Shank x .75 to nearest .001".} \end{array} \right.$

NOTES

Cut thread taps sizes smaller than $\frac{11}{32}''$ have external center on thread end; sizes $\frac{11}{32}''$ and larger have internal center in thread end.

Ground thread taps sizes smaller than $\frac{1}{4}''$ have external center on thread end; sizes $\frac{1}{4}''$ and larger have internal center in thread end.

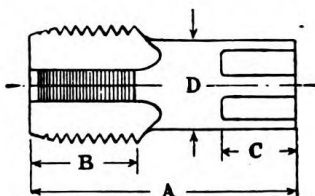
Exception: All taps to $\frac{3}{8}''$ inclusive having two flutes, three flutes or spiral point have external center on thread end.

For standard thread dimensions and limits see Tables 325, 326 and 327.

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TABLE 303

Special Fine Pitch Hand Taps



UNLESS otherwise specified, orders covering special hand taps $1\frac{1}{8}$ inch to $1\frac{1}{2}$ inch diameter inclusive having 14 or more threads per inch, and sizes over $1\frac{1}{2}$ inch diameter with 10 or more threads per inch, will be filled with taps having general dimensions as shown in the following table:

GENERAL DIMENSIONS

Diameter of Tap Inches	Dimensions—Inches				
	Length Overall A	Length of Full Thread B	Length of Square C	Diameter of Shank D	Size of Square E
$1\frac{1}{8}$	4	$1\frac{1}{2}$	$\frac{7}{8}$	.896	.672
$1\frac{1}{4}$	4	$1\frac{1}{2}$	1	1.021	.766
$1\frac{3}{8}$	4	$1\frac{1}{2}$	1	1.108	.831
$1\frac{1}{2}$	4	$1\frac{1}{2}$	1	1.233	.925
$1\frac{5}{8}$	5	2	$1\frac{1}{8}$	1.305	.979
$1\frac{3}{4}$	5	2	$1\frac{1}{4}$	1.430	1.072
$1\frac{7}{8}$	5	2	$1\frac{1}{4}$	1.519	1.139
2	5	2	$1\frac{3}{8}$	1.644	1.233
$2\frac{1}{8}$	$5\frac{1}{4}$	2	$1\frac{3}{8}$	1.769	1.327
$2\frac{1}{4}$	$5\frac{1}{4}$	2	$1\frac{7}{16}$	1.894	1.420
$2\frac{3}{8}$	$5\frac{1}{4}$	2	$1\frac{7}{16}$	2.019	1.514
$2\frac{1}{2}$	$5\frac{1}{4}$	2	$1\frac{1}{2}$	2.100	1.575
$2\frac{5}{8}$	$5\frac{1}{2}$	2	$1\frac{1}{2}$	2.100	1.575
$2\frac{3}{4}$	$5\frac{1}{2}$	2	$1\frac{1}{2}$	2.100	1.575
$2\frac{7}{8}$	$5\frac{1}{2}$	2	$1\frac{1}{2}$	2.100	1.575
3	$5\frac{1}{2}$	2	$1\frac{1}{2}$	2.100	1.575
$3\frac{1}{8}$	$5\frac{3}{4}$	2	$1\frac{1}{2}$	2.100	1.575
$3\frac{1}{4}$	$5\frac{3}{4}$	2	$1\frac{1}{2}$	2.100	1.575
$3\frac{3}{8}$	$5\frac{3}{4}$	2	$1\frac{1}{2}$	2.100	1.575
$3\frac{1}{2}$	$5\frac{3}{4}$	2	$1\frac{1}{2}$	2.100	1.575
$3\frac{5}{8}$	6	2	$1\frac{3}{4}$	2.100	1.575
$3\frac{3}{4}$	6	2	$1\frac{3}{4}$	2.100	1.575
$3\frac{7}{8}$	6	2	$1\frac{3}{4}$	2.100	1.575
4	6	2	$1\frac{3}{4}$	2.100	1.575

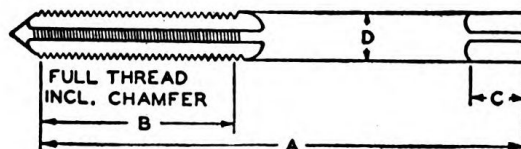
NOTES

For tolerances see Table 302.

For standard thread dimensions and limits see Tables 330 and 331.

★ "GREENFIELD" TOOLS ★

TABLE 304—Machine Screw Taps



GENERAL DIMENSIONS

Screw Gage Number	Dimensions—Inches						Size of Square E
	Length Overall A		Length of Full Thd. B		Length of Square C	Diam. of Shank D	
	Standard	Stub	Standard	Stub			
0	1 ⁵ / ₈	...	⁵ / ₁₆	..	³ / ₁₆	.141	.110
1	1 ¹¹ / ₁₆	...	³ / ₈	..	³ / ₁₆	.141	.110
2	1 ³ / ₄	1 ³ / ₄	⁷ / ₁₆	⁵ / ₁₆	³ / ₁₆	.141	.110
3	1 ¹³ / ₁₆	1 ³ / ₄	¹ / ₂	³ / ₈	³ / ₁₆	.141	.110
4	1 ⁷ / ₈	1 ³ / ₄	⁹ / ₁₆	⁷ / ₁₆	³ / ₁₆	.141	.110
5	1 ¹⁵ / ₁₆	1 ³ / ₄	⁵ / ₈	⁷ / ₁₆	³ / ₁₆	.141	.110
6	2	1 ³ / ₄	¹¹ / ₁₆	¹ / ₂	³ / ₁₆	.141	.110
7	2 ¹ / ₁₆	...	³ / ₄	..	¹ / ₄	.168	.131
8	2 ¹ / ₈	1 ³ / ₄	³ / ₄	⁹ / ₁₆	¹ / ₄	.168	.131
9	2 ¹ / ₄	...	¹³ / ₁₆	..	¹ / ₄	.194	.152
10	2 ³ / ₈	1 ³ / ₄	⁷ / ₈	⁵ / ₈	¹ / ₄	.194	.152
12	2 ³ / ₈	1 ³ / ₄	¹⁵ / ₁₆	¹¹ / ₁₆	⁹ / ₃₂	.220	.165
14	2 ¹ / ₂	...	1	..	⁹ / ₃₂	.247	.185
16	2 ¹ / ₂	...	1 ¹ / ₁₆	..	⁵ / ₁₆	.273	.205
18	2 ²³ / ₃₂	...	1 ¹ / ₁₆	..	⁵ / ₁₆	.299	.225
20	2 ²³ / ₃₂	...	1 ¹ / ₈	..	¹¹ / ₃₂	.325	.244

TOLERANCES

Element	Range Screw Gage Number	Direction	Tolerance, Inches	
			Cut Thread	Ground Thread
Length Overall—A	0 to 20 incl.	Plus or Minus	1/32	1/32
Length of Thread—B	0 to 12 incl.	Plus or Minus	3/64	3/64
	14 to 20 incl.	Plus or Minus	1/16	1/16
Length of Square—C	0 to 20 incl.	Plus or Minus	1/32	1/32
Diameter of Shank—D	0 to 12 incl.	Minus	.004	.0015
	14 to 20 incl.	Minus	.005	.0015
Size of Square—E	0 to 20 incl.	Minus	.004	.004

FORMULAE—(Approximate)

Diameter of Shank { No. 0 to No. 5 Incl. = Diameter of Shank of No. 6 Tap.
 { No. 6 to No. 20 Incl. = Approximate Maximum Major Diameter (except No. 7 and No. 9).

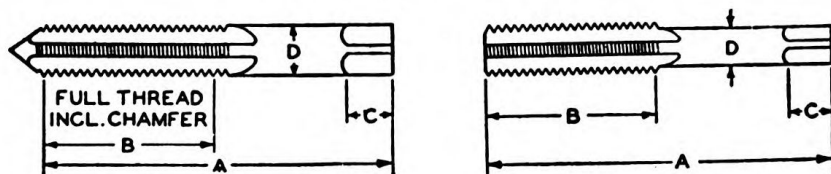
Size of Square { No. 0 to No. 10 Incl. = Diam. of Shank x .78 to nearest .001"
 { No. 12 to No. 20 Incl. = Diam. of Shank x .75 to nearest .001"

NOTES: All Taps have external center on thread end.

For standard thread dimensions and limits see Tables 328 and 329.

★ "GREENFIELD" TOOLS ★

TABLE 305—Stove Bolt Taps



GENERAL DIMENSIONS

Nominal Size of Tap	Length, Inches			Diameter of Shank Inches D	Size of Square Inches E	Corresponding Size Standard Tap Blank
	Overall A	Full Thread B	Square C			
$\frac{1}{8}$ -32	$1\frac{15}{16}$	$\frac{5}{8}$	$\frac{3}{16}$	.141	.110	No. 8 M. S.
$\frac{5}{32}$ -28	$2\frac{1}{8}$	$\frac{3}{4}$	$\frac{1}{4}$	.168	.131	
$\frac{3}{16}$ -24	$2\frac{3}{8}$	$\frac{7}{8}$	$\frac{1}{4}$	.201	.151	..
$\frac{7}{32}$ -22	$2\frac{3}{8}$	$1\frac{5}{16}$	$\frac{1}{4}$	.228	.171	..
$\frac{1}{4}$ -18	$2\frac{1}{2}$	1	$\frac{9}{32}$	.255	.191	$\frac{1}{4}$
$\frac{5}{16}$ -18	$2\frac{23}{32}$	$1\frac{1}{8}$	$\frac{5}{16}$	.318	.238	$\frac{5}{16}$
$\frac{3}{8}$ -16	$2\frac{15}{16}$	$1\frac{1}{4}$	$\frac{3}{8}$	.381	.286	$\frac{3}{8}$
$\frac{7}{16}$ -14	$3\frac{5}{32}$	$1\frac{7}{16}$	$\frac{13}{32}$	.323	.242	$\frac{7}{16}$
$\frac{1}{2}$ -13	$3\frac{3}{8}$	$1\frac{21}{32}$	$\frac{7}{16}$	.367	.275	$\frac{1}{2}$

TOLERANCES

Element	Range, Inches	Direction	Tolerance, Inches
Length Overall—A	$\frac{1}{8}$ to $\frac{1}{2}$ incl.	Plus or Minus	$\frac{1}{32}$
Length of Thread—B	$\frac{1}{8}$ to $\frac{7}{32}$ incl.	Plus or Minus	$\frac{3}{64}$
	$\frac{1}{4}$ to $\frac{1}{2}$ incl.	Plus or Minus	$\frac{1}{16}$
Length of Square—C	$\frac{1}{8}$ to $\frac{1}{2}$ incl.	Plus or Minus	$\frac{1}{32}$
Diameter of Shank—D	$\frac{1}{8}$ to $\frac{7}{32}$ incl.	Minus	.004
	$\frac{1}{4}$ to $\frac{1}{2}$ incl.	Minus	.005
Size of Square—E	$\frac{1}{8}$ to $\frac{1}{2}$ incl.	Minus	.004

FORMULAE—(Approximate)

Diameter of Shank	Large Shanks	$\frac{1}{8}$ " = Diameter of Shank of $\frac{1}{8}$ " Hand Tap. $\frac{5}{32}$ " and Larger = Approximate Maximum Major Diameter.
	Small Shanks	= Basic Major Diameter — (Std. V Pitch x 1.6 to nearest .001").
Size of Square	$\frac{1}{8}$ " to $\frac{5}{16}$ " Incl.	= Diameter of Shank x .78 to nearest .001".
	$\frac{3}{16}$ " and Larger	= Diameter of Shank x .75 to nearest .001".

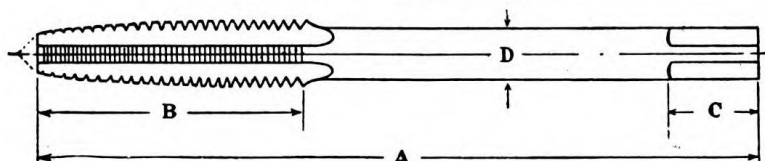
NOTES: Cut thread taps up to $\frac{5}{16}$ " inclusive have external center on thread end; sizes $\frac{3}{8}$ " and larger have internal center in thread end.

For standard thread dimensions and limits see Table 332.

These taps conform to the manufacturers' standard for stove bolts.

★ "GREENFIELD" TOOLS ★

TABLE 306—Nut Taps



GENERAL DIMENSIONS

Diam. of Tap Inches	Threads per Inch			Dimensions—Inches				
	NC	NF	NS	Length Overall A	Length of Thread B	Length of Square C	Diameter of Shank D	Size of Square E
$\frac{3}{16}$	..	..	24	$4\frac{1}{2}$	$1\frac{3}{8}$	$\frac{1}{2}$	.133	.100
$\frac{3}{16}$	..	..	32	$4\frac{1}{2}$	1	$\frac{1}{2}$	.133	.100
$\frac{1}{4}$	20	..	..	5	$1\frac{5}{8}$	$\frac{9}{16}$	.185	.139
$\frac{1}{4}$	..	28	..	5	$1\frac{1}{4}$	$\frac{9}{16}$	.185	.139
$\frac{5}{16}$	18	..	..	$5\frac{1}{2}$	$1\frac{13}{16}$	$\frac{5}{8}$	.240	.180
$\frac{5}{16}$	..	24	..	$5\frac{1}{2}$	$1\frac{3}{8}$	$\frac{5}{8}$	.240	.180
$\frac{3}{8}$	16	..	..	6	2	$\frac{11}{16}$	.294	.220
$\frac{3}{8}$	..	24	..	6	$1\frac{1}{2}$	$\frac{11}{16}$	.294	.220
$\frac{7}{16}$	14	..	..	$6\frac{1}{2}$	$2\frac{3}{8}$	$\frac{3}{4}$	.345	.259
$\frac{7}{16}$	..	20	..	$6\frac{1}{2}$	$1\frac{3}{4}$	$\frac{3}{4}$	.345	.259
$\frac{1}{2}$	13	..	..	7	$2\frac{1}{2}$	$\frac{7}{8}$	.400	.300
$\frac{1}{2}$	..	20	..	7	$1\frac{7}{8}$	$\frac{7}{8}$	.400	.300
$\frac{9}{16}$	12	..	..	$7\frac{1}{2}$	$2\frac{3}{4}$	$\frac{7}{8}$	.450	.337
$\frac{9}{16}$	..	18	..	$7\frac{1}{2}$	2	$\frac{7}{8}$	.450	.337
$\frac{5}{8}$	11	..	..	8	3	$\frac{15}{16}$	.503	.377
$\frac{5}{8}$	..	18	..	8	$2\frac{1}{4}$	$\frac{15}{16}$	.503	.377
$\frac{11}{16}$	..	..	11	$8\frac{1}{2}$	3	1	.565	.424
$\frac{11}{16}$	..	..	16	$8\frac{1}{2}$	$2\frac{1}{4}$	1	.565	.424
$\frac{3}{4}$	10	..	..	9	$3\frac{1}{4}$	1	.616	.462
$\frac{3}{4}$	..	16	..	9	$2\frac{1}{2}$	1	.616	.462
$\frac{13}{16}$	..	..	10	$9\frac{1}{2}$	$3\frac{1}{4}$	$1\frac{1}{16}$	.679	.509
$\frac{7}{8}$	9	..	..	10	$3\frac{5}{8}$	$1\frac{1}{16}$	.727	.545
$\frac{7}{8}$	..	14	..	10	$2\frac{3}{8}$	$1\frac{1}{16}$	.727	.545
$\frac{7}{8}$	..	..	18	10	$2\frac{3}{4}$	$1\frac{1}{16}$	.727	.545
$\frac{15}{16}$	..	..	9	$10\frac{1}{2}$	$3\frac{5}{8}$	$1\frac{1}{8}$	.789	.592
1	8	..	..	11	4	$1\frac{1}{8}$	.834	.625
1	..	14	..	11	3	$1\frac{1}{8}$	.834	.625
$1\frac{1}{8}$	7	..	..	$11\frac{1}{2}$	$4\frac{3}{4}$	$1\frac{1}{4}$	.933	.700
$1\frac{1}{8}$	..	12	..	$11\frac{1}{2}$	$3\frac{1}{2}$	$1\frac{1}{4}$	.933	.700
$1\frac{1}{4}$	7	..	..	12	$4\frac{3}{4}$	$1\frac{5}{16}$	1.058	.793
$1\frac{1}{4}$	..	12	..	12	$3\frac{1}{2}$	$1\frac{5}{16}$	1.058	.793
$1\frac{3}{8}$	6	$12\frac{1}{2}$	$5\frac{3}{8}$	$1\frac{3}{8}$	1.153	.865
$1\frac{3}{8}$..	12	..	$12\frac{1}{2}$	4	$1\frac{3}{8}$	1.153	.865
$1\frac{1}{2}$	6	13	$5\frac{3}{8}$	$1\frac{1}{2}$	1.278	.958
$1\frac{1}{2}$..	12	..	13	4	$1\frac{1}{2}$	1.278	.958

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★ "GREENFIELD" TOOLS ★

TABLE 306—Nut Taps
(Concluded)
GENERAL DIMENSIONS

Diam. of Tap Inches	Threads per Inch			Dimensions—Inches				
	NC	NF	NS	Length Overall A	Length of Thread B	Length of Square C	Diameter of Shank D	Size of Square E
$1\frac{5}{8}$	...	..	$5\frac{1}{2}$	$13\frac{1}{2}$	$5\frac{1}{2}$	$1\frac{9}{16}$	1.383	1.037
$1\frac{3}{4}$	5	..	...	14	$5\frac{1}{2}$	$1\frac{5}{8}$	1.484	1.113
$1\frac{7}{8}$	...	..	5	$14\frac{1}{2}$	$5\frac{1}{2}$	$1\frac{11}{16}$	1.609	1.207
2	$4\frac{1}{2}$	..	...	15	$6\frac{1}{8}$	$1\frac{3}{4}$	1.705	1.279
$2\frac{1}{8}$	...	..	$4\frac{1}{2}$	$15\frac{1}{2}$	$6\frac{1}{8}$	$1\frac{13}{16}$	1.828	1.371
$2\frac{1}{4}$	$4\frac{1}{2}$	..	...	16	$6\frac{1}{8}$	$1\frac{7}{8}$	1.953	1.465
$2\frac{3}{8}$	...	..	4	$16\frac{1}{2}$	$6\frac{7}{8}$	2	2.042	1.531
$2\frac{1}{2}$	4	..	...	17	$6\frac{7}{8}$	2	2.167	1.625

TOLERANCES

Element	Range Inches	Direction	Tolerance, Inches	
			Cut Thread	Ground Thread
Length Overall—A	$\left\{ \begin{array}{l} \frac{3}{16} \text{ to } 1 \text{ incl.} \\ 1 \frac{1}{8} \text{ to } 2\frac{1}{2} \text{ incl.} \end{array} \right.$	$\left\{ \begin{array}{l} \text{Plus or Minus} \\ \text{Plus or Minus} \end{array} \right.$	$\left\{ \begin{array}{l} \frac{1}{16} \\ \frac{3}{32} \end{array} \right.$	$\left\{ \begin{array}{l} \frac{1}{16} \\ \frac{3}{32} \end{array} \right.$
Length of Thread—B	$\left\{ \begin{array}{l} \frac{3}{16} \text{ to } \frac{1}{2} \text{ incl.} \\ \frac{9}{16} \text{ to } 1\frac{1}{2} \text{ incl.} \\ 1 \frac{5}{8} \text{ to } 2\frac{1}{2} \text{ incl.} \end{array} \right.$	$\left\{ \begin{array}{l} \text{Plus or Minus} \\ \text{Plus or Minus} \\ \text{Plus or Minus} \end{array} \right.$	$\left\{ \begin{array}{l} \frac{1}{16} \\ \frac{3}{32} \\ \frac{1}{8} \end{array} \right.$	$\left\{ \begin{array}{l} \frac{1}{16} \\ \frac{3}{32} \\ \frac{1}{8} \end{array} \right.$
Length of Square—C	$\left\{ \begin{array}{l} \frac{3}{16} \text{ to } \frac{5}{8} \text{ incl.} \\ \frac{11}{16} \text{ to } 1\frac{1}{2} \text{ incl.} \\ 1 \frac{5}{8} \text{ to } 2\frac{1}{2} \text{ incl.} \end{array} \right.$	$\left\{ \begin{array}{l} \text{Plus or Minus} \\ \text{Plus or Minus} \\ \text{Plus or Minus} \end{array} \right.$	$\left\{ \begin{array}{l} \frac{1}{32} \\ \frac{3}{64} \\ \frac{1}{16} \end{array} \right.$	$\left\{ \begin{array}{l} \frac{1}{32} \\ \frac{3}{64} \\ \frac{1}{16} \end{array} \right.$
Diameter of Shank—D	$\left\{ \begin{array}{l} \frac{3}{16} \text{ to } \frac{1}{2} \text{ incl.} \\ \frac{9}{16} \text{ to } 1 \text{ incl.} \\ 1 \frac{1}{8} \text{ to } 2 \text{ incl.} \\ 2 \frac{1}{8} \text{ to } 2\frac{1}{2} \text{ incl.} \end{array} \right.$	$\left\{ \begin{array}{l} \text{Minus} \\ \text{Minus} \\ \text{Minus} \\ \text{Minus} \end{array} \right.$	$\left\{ \begin{array}{l} .005 \\ .006 \\ .008 \\ .010 \end{array} \right.$	$\left\{ \begin{array}{l} .005 \\ .006 \\ .008 \\ .010 \end{array} \right.$
Size of Square—E	$\left\{ \begin{array}{l} \frac{3}{16} \text{ to } \frac{1}{2} \text{ incl.} \\ \frac{9}{16} \text{ to } 1 \text{ incl.} \\ 1 \frac{1}{8} \text{ to } 2 \text{ incl.} \\ 2 \frac{1}{8} \text{ to } 2\frac{1}{2} \text{ incl.} \end{array} \right.$	$\left\{ \begin{array}{l} \text{Minus} \\ \text{Minus} \\ \text{Minus} \\ \text{Minus} \end{array} \right.$	$\left\{ \begin{array}{l} .004 \\ .006 \\ .008 \\ .010 \end{array} \right.$	$\left\{ \begin{array}{l} .004 \\ .006 \\ .008 \\ .010 \end{array} \right.$

FORMULAE—(Approximate)

Diameter of Shank $\left\{ \begin{array}{l} \frac{3}{16}'' \text{ to } \frac{1}{2}'' \text{ Incl.} = \text{NC Basic Root Diameter.} \\ \frac{9}{16}'' \text{ to } 1'' \text{ Incl.} = \text{NC Basic Root Diameter Minus .004\"} \\ 1\frac{1}{8}'' \text{ to } 2'' \text{ Incl.} = \text{NC Basic Root Diameter Minus .006\"} \\ 2\frac{1}{8}'' \text{ to } 2\frac{1}{2}'' \text{ Incl.} = \text{NC Basic Root Diameter Minus .008\"} \end{array} \right.$

Size of Square = Diameter of Shank x .75 to nearest .001".

NOTES: Cut thread taps have external center on thread end in sizes up to $1\frac{3}{8}$ inch inclusive and internal centers in sizes $\frac{1}{16}$ inch and larger.

Ground thread taps have external center on thread end in sizes up to $1\frac{3}{4}$ inch inclusive and internal centers in sizes $\frac{1}{4}$ inch and larger.

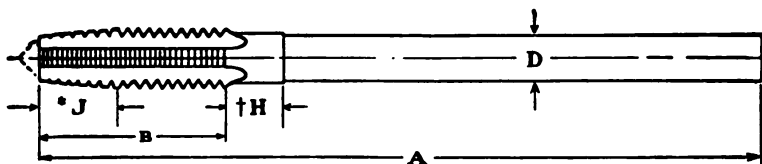
For standard thread dimensions and limits see Tables 325 and 326.

★ "GREENFIELD" TOOLS ★

TABLE 307

Tapper Taps

Fractional Sizes



GENERAL DIMENSIONS

Diam. of Tap Inches	Threads per Inch			Dimensions—Inches			
	NC	NF	NS	Length Overall A	Length of Thread B	Diameter of Shank D	Nut Guide H
1/4	20	..	..	12	1 1/4	.185	..
1/4	..	28	..	12	1	.185	1/4
5/16	18	..	..	12	1 3/8	.240	..
5/16	..	24	..	12	1 1/16	.240	5/16
3/8	16	..	..	12	1 9/16	.294	..
3/8	..	24	..	12	1 3/16	.294	3/8
7/16	14	..	..	12	1 13/16	.345	..
7/16	..	20	..	12	1 3/8	.345	7/16
1/2	13	..	..	12 and 15	1 7/8	.400	..
1/2	..	20	..	12 and 15	1 3/8	.400	1/2
9/16	12	..	..	12 and 15	2 1/8	.450	..
9/16	..	18	..	12 and 15	1 9/16	.450	9/16
5/8	11	..	..	12 and 15	2 5/16	.503	..
5/8	..	18	..	12 and 15	1 11/16	.503	5/8
11/16	..	..	11	12 and 15	2 5/16	.565	..
11/16	..	..	16	12 and 15	1 11/16	.565	5/8
3/4	10	..	..	12 and 15	2 1/2	.616	..
3/4	..	16	..	12 and 15	1 3/4	.616	3/4
13/16	..	..	10	12 and 15	2 1/2	.679	..
7/8	9	..	..	12 and 15	2 3/4	.727	..
7/8	..	14	..	12 and 15	1 7/8	.727	7/8
7/8	..	..	18	12 and 15	1 7/8	.727	7/8
15/16	..	..	9	12 and 15	2 3/4	.789	..
1	8	..	..	12 and 15	3 1/8	.834	..
1	..	14	..	12 and 15	2 1/8	.834	1

(Concluded on following page)

★ "GREENFIELD" TOOLS ★

TABLE 307
(Concluded)
Tapper Taps
Fractional Sizes

GENERAL DIMENSIONS

Diameter of Tap Inches	Threads per Inch			Dimensions—Inches			
	NC	NF	NS	Length Overall A	Length of Thread B	Diameter of Shank D	Nut Guide H
$1\frac{1}{8}$	7	..	...	15	$3\frac{1}{2}$	.933	...
$1\frac{1}{8}$	...	12	...	15	$2\frac{3}{8}$	.933	$1\frac{1}{8}$
$1\frac{1}{4}$	7	..	...	15	$3\frac{1}{2}$	1.058	...
$1\frac{1}{4}$	...	12	...	15	$2\frac{3}{8}$	1.058	$1\frac{1}{8}$
$1\frac{3}{8}$	6	..	...	15	4	1.153	...
$1\frac{3}{8}$	...	12	...	15	$2\frac{5}{8}$	1.153	$1\frac{3}{8}$
$1\frac{1}{2}$	6	..	...	15	4	1.278	...
$1\frac{1}{2}$	...	12	...	15	$2\frac{5}{8}$	1.278	$1\frac{3}{8}$
$1\frac{5}{8}$	...	..	$5\frac{1}{2}$	15	4	1.383	...
$1\frac{3}{4}$	5	..	...	15	$4\frac{1}{2}$	1.484	...
$1\frac{7}{8}$	...	..	5	15	$4\frac{1}{2}$	1.609	...
2	$4\frac{1}{2}$	..	...	15	$4\frac{1}{2}$	1.705	...

TOLERANCES

Element	Range Inches	Direction	Tolerance, Inches	
			Cut Thread	Ground Thread
Length Overall—A	$\left\{ \begin{array}{l} \frac{1}{4} \text{ to } 1 \text{ incl.} \\ 1\frac{1}{8} \text{ to } 2 \text{ incl.} \end{array} \right.$	Plus or Minus Plus or Minus	$\frac{1}{8}$ $\frac{3}{16}$	$\frac{1}{8}$ $\frac{3}{16}$
Length of Thread—B	$\left\{ \begin{array}{l} \frac{1}{4} \text{ to } \frac{1}{2} \text{ incl.} \\ \frac{9}{16} \text{ to } 1\frac{1}{2} \text{ incl.} \\ 1\frac{5}{8} \text{ to } 2 \text{ incl.} \end{array} \right.$	Plus or Minus Plus or Minus Plus or Minus	$\frac{1}{16}$ $\frac{3}{32}$ $\frac{1}{8}$	$\frac{1}{16}$ $\frac{3}{32}$ $\frac{1}{8}$
Diameter of Shank—D	$\left\{ \begin{array}{l} \frac{1}{4} \text{ to } \frac{1}{2} \text{ incl.} \\ \frac{9}{16} \text{ to } 1 \text{ incl.} \\ 1\frac{1}{8} \text{ to } 2 \text{ incl.} \end{array} \right.$	Minus Minus Minus	.005 .006 .008	.005 .006 .008

FORMULAE—(Approximate)

Diam. of Shank $\left\{ \begin{array}{l} \frac{1}{4}'' \text{ to } \frac{1}{2}'' \text{ Incl.} = \text{NC Basic Root Diameter.} \\ \frac{5}{16}'' \text{ to } 1'' \text{ Incl.} = \text{NC Basic Root Diam. Minus .004\"} \\ 1\frac{1}{8}'' \text{ to } 2'' \text{ Incl.} = \text{NC Basic Root Diam. Minus .006\"} \end{array} \right.$

NOTES

A nut guide "H," approximately equal in diameter to the basic root diameter, may be furnished on taps having threads NF and finer.

*The chamfer "J" is 11 to 12 threads for National Coarse Thread taps and 15 to 17 threads for National Fine Threads taps.

Cut thread taps up to $1\frac{3}{4}''$ inclusive have external center on thread end; sizes $\frac{1}{16}''$ and larger have internal center in thread end.

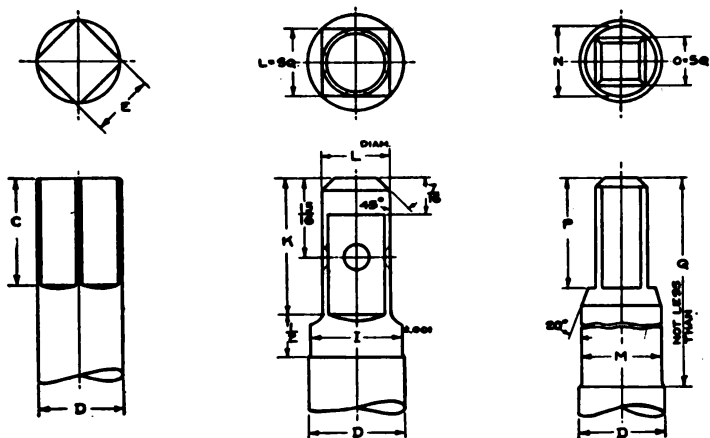
Ground thread taps have internal center in thread end.

Tapper taps are furnished with plain round shank unless otherwise ordered. For other styles of shanks see Table 308.

For standard thread dimensions and limits see Tables 325 and 326.

"GREENFIELD" TOOLS

TABLE 308
Tapper Tap Shanks



Plain Round or Squared

Acme Improved Type "C"

National Interchangeable Ring Lock

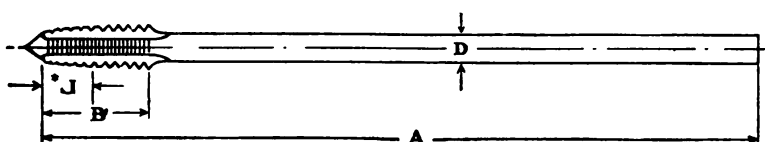
GENERAL DIMENSIONS

Diam. of Tap Inches	Dimensions—Inches										
	C	D	E	I	K	L	M	N	O	P	Q
1/4	9/16	.185	.139	.177	15/16	.147	.185	.170	.134	11/16	2 1/2
5/16	5/8	.240	.180	.232	15/16	.188	.240	.221	.165	11/16	2 1/2
3/8	11/16	.294	.220	.286	15/16	.240	.290	.271	.208	11/16	2 1/2
7/16	3/4	.345	.259	.336	15/16	.290	.340	.320	.240	11/16	2 1/2
1/2	7/8	.400	.300	.390	15/16	.320	.400	.374	.286	1	3 1/4
9/16	7/8	.450	.337	.446	15/16	.350	.450	.422	.318	1	3 1/4
5/8	15/16	.503	.377	.500	15/16	.390	.500	.450	.350	1	3 1/4
11/16	1	.565	.424	.554	15/16	.430	.565	.515	.390	1 5/16	3 3/4
3/4	1	.616	.462	.610	15/16	.480	.615	.540	.422	1 5/16	3 3/4
13/16	1 1/16	.679	.509	.659	15/16	.540	.675	.620	.465	1 5/16	3 3/4
7/8	1 1/16	.727	.545	.722	15/16	.540	.720	.630	.500	1 5/16	3 3/4
15/16	1 1/8	.789	.592	.774	15/16	.580	.785	.727	.545	1 5/16	3 3/4
1	1 1/8	.834	.625	.829	15/8	.650	.825	.730	.574	1 5/16	3 3/4
1 1/8	1 1/4	.933	.700	.929	15/8	.710	.930	.855	.667	1 3/4	4 1/2
1 1/4	1 5/16	1.058	.793	1.053	15/8	.780	1.055	.975	.760	1 3/4	4 1/2
1 3/8	1 3/8	1.153	.865	1.149	15/8	.850	1.150	1.055	.824	1 3/4	4 1/2
1 1/2	1 1/2	1.278	.958	1.269	15/8	.950	1.275	1.195	.917	1 3/4	4 1/2
1 5/8	1 9/16	1.383	1.037	1.328	15/8	1.000	1.375	1.319	.995	2 1/16	4 3/4
1 3/4	1 5/8	1.484	1.113	1.436	15/8	1.062	1.480	1.421	1.070	2 1/16	4 3/4
1 7/8	1 11/16	1.609	1.207	1.594	15/8	1.187	1.605	1.548	1.167	2 1/16	4 3/4
2	1 3/4	1.705	1.279	1.696	15/8	1.250	1.700	1.641	1.230	2 1/16	4 3/4

NOTE: For tolerances on size of squares see Table 306.

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TABLE 309
Tapper Taps
Machine Screw Sizes



GENERAL DIMENSIONS

Screw Gage Number	Threads per Inch			Dimensions—Inches		
	NC	NF	NS	Length Overall A	Length of Thread B	Diameter of Shank D
2	56	..	..	5	$\frac{11}{32}$	.063
2	..	64	..	5	$\frac{5}{16}$	.066
3	48	..	..	5	$\frac{13}{32}$	.072
3	..	56	..	5	$\frac{11}{32}$	.076
4	..	..	36	6	$\frac{9}{16}$	.076
4	40	..	..	6	$\frac{1}{2}$	.080
4	..	48	..	6	$\frac{13}{32}$	.085
5	40	..	..	8	$\frac{1}{2}$	.093
5	..	44	..	8	$\frac{7}{16}$	.096
6	32	..	..	8	$\frac{5}{8}$	.097
6	..	40	..	8	$\frac{1}{2}$	.106
8	32	..	..	9	$\frac{5}{8}$	.123
8	..	36	..	9	$\frac{9}{16}$	.128
10	24	..	..	11	$\frac{13}{16}$	.136
10	..	32	..	11	$\frac{5}{8}$	.149
12	24	..	..	11	$\frac{13}{16}$	.162
12	..	28	..	11	$\frac{23}{32}$	.170
14	..	..	20	11	1	.177
14	..	..	24	11	$\frac{13}{16}$	.188

TOLERANCES

Element	Range	Direction	Tolerance, Inches
Length Overall (A)	Sizes 2 to 14 incl.	Plus or Minus	$\frac{1}{16}$
Length of Thread (B)	Sizes 2 to 14 incl.	Plus or Minus	$\frac{3}{64}$
Diameter of Shank (D)	Sizes 2 to 14 incl.	Minus	.005

FORMULAE—(Approximate)

Diameter of Shank = National Basic Root Diameter to nearest .001".

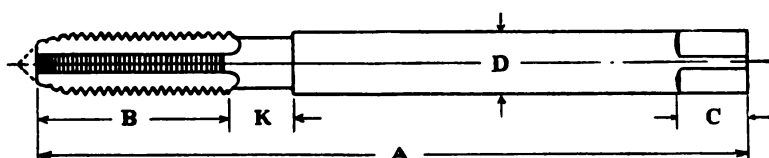
NOTES

For Standard Thread Dimensions and Limits see Table 328.

*The chamfer "J" is 11 to 12 threads.

★ "GREENFIELD" TOOLS ★

TABLE 310
Pulley Taps



GENERAL DIMENSIONS

Diameter of Tap Inches	Dimensions—Inches					
	Length Overall A	Length of Thread B	Length of Square C	Diameter of Shank D	Size of Square E	Length of Neck K
$\frac{1}{4}$	6, 8	1	$\frac{5}{16}$	.255	.191	$\frac{3}{8}$
$\frac{5}{16}$	6, 8	$1 \frac{1}{8}$	$\frac{3}{8}$	.318	.238	$\frac{3}{8}$
$\frac{3}{8}$	6, 8, 10	$1 \frac{1}{4}$	$\frac{7}{16}$	.381	.286	$\frac{3}{8}$
$\frac{7}{16}$	6, 8, 10, 12	$1 \frac{7}{16}$	$\frac{1}{2}$	.444	.333	$\frac{7}{16}$
$\frac{1}{2}$	6, 8, 10, 12	$1 \frac{21}{32}$	$\frac{9}{16}$	.507	.380	$\frac{1}{2}$
$\frac{5}{8}$	6, 8, 10, 12, 14	$1 \frac{13}{16}$	$1 \frac{1}{16}$	.633	.475	$\frac{5}{8}$
$\frac{3}{4}$	10, 12, 14	2	$\frac{3}{4}$	.759	.569	$\frac{3}{4}$

TOLERANCES

Element	Range Inches	Direction	Tolerance, Inches	
			Cut Thread	Ground Thread
Length Overall—A	$\frac{1}{4}$ to $\frac{3}{4}$ incl.	Plus or Minus	$\frac{1}{16}$	$\frac{1}{16}$
Length of Thread—B	$\frac{1}{4}$ to $\frac{3}{4}$ incl.	Plus or Minus	$\frac{1}{16}$	$\frac{1}{16}$
Length of Square—C	$\frac{1}{4}$ to $\frac{3}{4}$ incl.	Plus or Minus	$\frac{1}{32}$	$\frac{1}{32}$
Diameter of Shank—D	$\frac{1}{4}$ to $\frac{3}{4}$ incl.	Minus	.005	.005
Size of Square—E	$\frac{1}{4}$ to $\frac{1}{2}$ incl.	Minus	.004	.004
	$\frac{5}{8}$ to $\frac{3}{4}$ incl.	Minus	.006	.006

FORMULAE—(Approximate)

Diameter of Shank = Maximum Major Diameter.

Size of Square = Diameter of Shank x .75 to nearest .001 inch.

NOTES

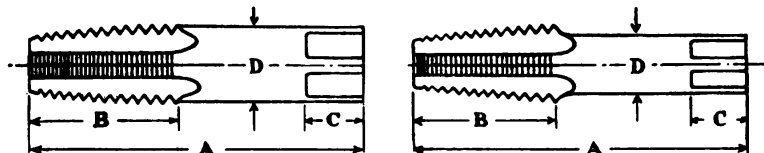
Cut thread taps have external center in thread end in sizes $\frac{1}{4}$ inch and $\frac{5}{16}$ inch, and internal center in sizes $\frac{3}{8}$ inch and larger.

Ground thread taps have internal center in thread end.

For standard thread dimensions and limits see Tables 325 and 326.

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TABLE 311
Pipe Taps



GENERAL DIMENSIONS

Nominal Size Inches	Dimensions—Inches				
	Length Overall A	Length of Thread B	Length of Square C	Diameter of Shank D	Size of Square E
1/8	2 1/8	3/4	3/8	.3125	.234
1/8	2 1/8	3/4	3/8	.4375	.328
1/4	2 1/4	1 1/16	1/2	.5625	.421
3/8	2 9/16	1 1/16	1/2	.7000	.531
1/2	3 1/8	1 3/8	3/4	.6875	.515
5/8	3 1/4	1 3/8	3/4	.8125	.594
3/4	3 1/4	1 3/8	1 1/16	.9063	.679
7/8	3 1/2	1 9/16	3/4	1.0937	.812
1	3 3/4	1 3/4	1 1/16	1.1250	.843
1 1/4	4	1 3/4	1 1/16	1.3125	.984
1 1/2	4 1/4	1 3/4	1	1.5000	1.125
1 3/4	4 3/8	1 3/4	1 1/16	1.6250	1.218
2	4 1/2	1 3/4	1 1/8	1.8750	1.406
2 1/4	5	2 1/8	1 3/16	2.0000	1.500
2 1/2	5 1/2	2 9/16	1 1/4	2.2500	1.687
2 3/4	5 3/4	2 9/16	1 5/16	2.3750	1.781
3	6	2 5/8	1 3/8	2.6250	1.968
3 1/4	6 1/4	2 5/8	1 7/16	2.7500	2.062
3 1/2	6 1/2	2 11/16	1 1/2	2.8125	2.108
3 3/4	6 5/8	2 11/16	1 9/16	2.8750	2.156
4	6 3/4	2 3/4	1 5/8	3.0000	2.250

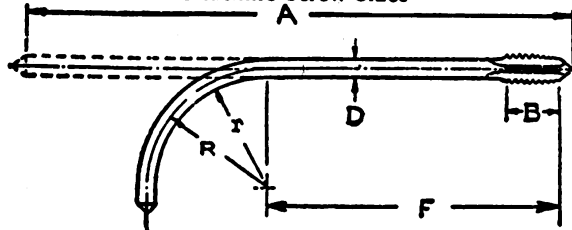
TOLERANCES

Element	Range Inches	Direction	Tolerance Inches	
			Cut Thread	Ground Thread
Length Overall—A	{ 1/8 to 3/4 incl. 7/8 to 4 incl.	Plus or Minus Plus or Minus	1/16 1/16	1/16 1/16
Length of Thread—B	{ 1/8 to 3/4 incl. 7/8 to 1 1/4 incl. 1 1/2 to 4 incl.	Plus or Minus Plus or Minus Plus or Minus	1/16 3/16 1/8	1/16 3/16 1/8
Length of Square —C	{ 1/8 to 3/4 incl. 7/8 to 4 incl.	Plus or Minus Plus or Minus	1/16 1/16	1/16 1/16
Diameter of Shank—D	{ 1/8 to 1/2 incl. 5/8 to 4 incl.	Minus Minus	.007 .009	.007 .009
Size of Square—E	{ 1/8 1/4 to 3/4 incl. 7/8 to 4 incl.	Minus Minus Minus	.004 .006 .008	.004 .006 .008

NOTE: For thread dimensions and limits see Tables 334, 335 and 338.

★ "GREENFIELD" TOOLS ★

TABLE 312—Bent Shank Tapper Taps
Machine Screw Sizes



GENERAL DIMENSIONS

Screw Gage No.	Basic Major Diam. Inches	Size of Mach. Inches	Threads per Inch			No. of Flutes	Dimensions—Inches					
			NC	NF	NS		A	B	D	F	R	r
4	.112	$\frac{1}{8}$	..	..	36	3	$3 \frac{9}{16}$	$11 \frac{1}{32}$	.076	$1 \frac{25}{32}$	$\frac{7}{8}$	.837
4	.112	$\frac{1}{8}$	40	..	..	3	$3 \frac{9}{16}$	$\frac{5}{16}$	.080	$1 \frac{25}{32}$	$\frac{7}{8}$	.836
4	.112	$\frac{1}{8}$	..	48	..	3	$3 \frac{9}{16}$	$\frac{1}{4}$	.085	$1 \frac{25}{32}$	$\frac{7}{8}$	.832
5	.125	$\frac{1}{8}$	40	..	..	3	$3 \frac{9}{16}$	$\frac{5}{16}$	.093	$1 \frac{25}{32}$	$\frac{7}{8}$	.829
5	.125	$\frac{1}{8}$	..	44	..	3	$3 \frac{9}{16}$	$\frac{9}{32}$	.095	$1 \frac{25}{32}$	$\frac{7}{8}$	.827
6	.138	$\frac{1}{8}$	32	..	..	3	$3 \frac{9}{16}$	$\frac{9}{32}$	.095	$1 \frac{25}{32}$	$\frac{7}{8}$	.827
6	.138	$\frac{1}{8}$	..	40	..	3	$3 \frac{9}{16}$	$\frac{5}{16}$	.104	$1 \frac{25}{32}$	$\frac{7}{8}$	.823
6	.138	$\frac{3}{16}$	32	..	..	3	$4 \frac{15}{16}$	$\frac{3}{8}$	.095	$2 \frac{15}{32}$	$1 \frac{3}{16}$	1.140
6	.138	$\frac{3}{16}$	..	40	..	3	$4 \frac{15}{16}$	$\frac{5}{16}$	.104	$2 \frac{15}{32}$	$1 \frac{3}{16}$	1.136
8	.164	$\frac{3}{16}$	32	..	..	3	$4 \frac{15}{16}$	$\frac{3}{8}$	.121	$2 \frac{7}{16}$	$1 \frac{3}{16}$	1.127
8	.164	$\frac{3}{16}$	..	36	..	3	$4 \frac{15}{16}$	$11 \frac{1}{32}$	.126	$2 \frac{7}{16}$	$1 \frac{3}{16}$	1.125
10	.190	$\frac{3}{16}$	24	..	..	3	$4 \frac{15}{16}$	$\frac{1}{2}$	.134	$2 \frac{15}{32}$	$1 \frac{3}{16}$	1.121
10	.190	$\frac{3}{16}$	..	32	..	3	$4 \frac{15}{16}$	$\frac{3}{8}$	.147	$2 \frac{15}{32}$	$1 \frac{3}{16}$	1.114
12	.216	$\frac{3}{16}$	24	..	..	3	$4 \frac{15}{16}$	$\frac{1}{2}$	.157	$2 \frac{3}{8}$	$1 \frac{3}{16}$	1.109
12	.216	$\frac{3}{16}$	..	28	..	3	$4 \frac{15}{16}$	$\frac{7}{16}$	.165	$2 \frac{3}{8}$	$1 \frac{3}{16}$	1.105
6	.138	$\frac{1}{4}$	32	..	..	3	$6 \frac{1}{2}$	$\frac{3}{8}$	.095	$3 \frac{25}{32}$	$1 \frac{1}{4}$	1.202
6	.138	$\frac{1}{4}$	..	40	..	3	$6 \frac{1}{2}$	$\frac{5}{16}$	.104	$3 \frac{25}{32}$	$1 \frac{1}{4}$	1.198
8	.164	$\frac{1}{4}$	32	..	..	3	$6 \frac{1}{2}$	$\frac{3}{8}$	.121	$3 \frac{3}{4}$	$1 \frac{1}{4}$	1.190
8	.164	$\frac{1}{4}$	..	36	..	3	$6 \frac{1}{2}$	$11 \frac{1}{32}$	.126	$3 \frac{3}{4}$	$1 \frac{1}{4}$	1.187
10	.190	$\frac{1}{4}$	24	..	..	3	$6 \frac{1}{2}$	$\frac{1}{2}$	.134	$3 \frac{25}{32}$	$1 \frac{1}{4}$	1.183
10	.190	$\frac{1}{4}$	..	32	..	3	$6 \frac{1}{2}$	$\frac{3}{8}$	.147	$3 \frac{25}{32}$	$1 \frac{1}{4}$	1.176
12	.216	$\frac{1}{4}$	24	..	..	3	$6 \frac{1}{2}$	$\frac{1}{2}$	.157	$3 \frac{11}{16}$	$1 \frac{1}{4}$	1.171
12	.216	$\frac{1}{4}$	..	28	..	3	$6 \frac{1}{2}$	$\frac{7}{16}$	.165	$3 \frac{11}{16}$	$1 \frac{1}{4}$	1.167
14	.242	$\frac{1}{4}$	..	..	20	3	$6 \frac{1}{2}$	$19 \frac{1}{32}$	.172	$3 \frac{21}{32}$	$1 \frac{1}{4}$	1.164
14	.242	$\frac{1}{4}$	..	..	24	3	$6 \frac{1}{2}$	$\frac{1}{2}$	.183	$3 \frac{21}{32}$	$1 \frac{1}{4}$	1.158

TOLERANCES

Element	Range Screw Gage Number	Direction	Tolerance Inches
Length Overall—A	4 to 14 incl.	Plus	$\frac{1}{16}$
Length of Thread—B	4 to 14 incl.	Plus or Minus	$\frac{3}{64}$
Diameter of Shank—D	4 to 14 incl.	Minus	.005

FORMULAE (Approximate)

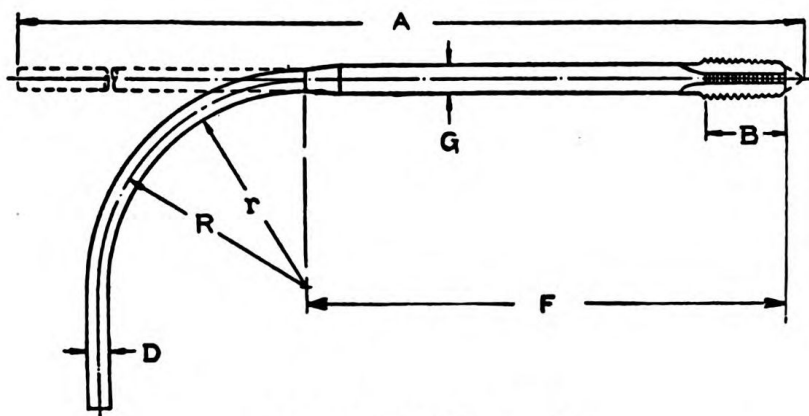
Diameter of Shank { No. 5 and smaller = National Basic Root Diameter.
 No. 6 to No. 10 incl. = National Basic Root Diameter minus .002".
 No. 12 and larger = National Basic Root Diameter minus .005".
 All to nearest .001".

NOTES: All taps have external center on thread end.

For standard thread limits and tolerances see Table 328.

★ "GREENFIELD" TOOLS ★

TABLE 313—Bent Shank Tapper Taps
Fractional Sizes



GENERAL DIMENSIONS

Diam. of Tap, In.	Size of Mach. Inches	Threads per Inch				No. of Flutes	Dimensions—Inches						
		NC	NF	NS	SB		A	B	D	F	G	R	r
$\frac{5}{32}$	$\frac{3}{16}$	..	..	..	28	3	$\frac{41}{16}$	$\frac{7}{16}$	.128	$2\frac{7}{16}$	..	$\frac{13}{16}$	1.124
$\frac{3}{16}$	$\frac{3}{16}$	..	..	..	24	3	$\frac{41}{16}$	$\frac{1}{2}$	.153	$2\frac{7}{16}$	..	$\frac{13}{16}$	1.111
$\frac{1}{8}$	$\frac{1}{4}$	..	..	40	..	3	$6\frac{1}{2}$	$\frac{5}{16}$	.093	$3\frac{3}{4}$	..	$\frac{11}{4}$	1.204
$\frac{5}{32}$	$\frac{1}{4}$	..	..	..	28	3	$6\frac{1}{2}$	$\frac{7}{16}$	.128	$3\frac{3}{4}$	..	$\frac{11}{4}$	1.186
$\frac{3}{16}$	$\frac{1}{4}$	..	..	24	..	3	$6\frac{1}{2}$	$\frac{1}{2}$	.133	$3\frac{3}{4}$	..	$\frac{11}{4}$	1.183
$\frac{3}{16}$	$\frac{1}{4}$	..	..	32	..	3	$6\frac{1}{2}$	$\frac{3}{8}$	.147	$3\frac{3}{4}$	..	$\frac{11}{4}$	1.176
$\frac{3}{16}$	$\frac{1}{4}$	..	..	..	24	3	$6\frac{1}{2}$	$\frac{1}{2}$	.153	$3\frac{3}{4}$	..	$\frac{11}{4}$	1.174
$\frac{1}{4}$	$\frac{1}{4}$	20	..	..	..	3	$6\frac{1}{2}$	$\frac{5}{8}$	.180	$3\frac{31}{32}$	..	$\frac{11}{4}$	1.160
$\frac{1}{4}$	$\frac{1}{4}$	..	28	..	..	3	$6\frac{1}{2}$	$\frac{5}{8}$	.194	$3\frac{5}{8}$	..	$\frac{11}{4}$	1.153
$\frac{1}{4}$	$\frac{1}{4}$	..	..	..	18	3	$6\frac{1}{2}$	$\frac{11}{16}$	.200	$3\frac{11}{16}$	..	$\frac{11}{4}$	1.150
$\frac{5}{16}$	$\frac{1}{4}$	18	..	..	..	3	$6\frac{1}{2}$	$\frac{11}{16}$	.235	$3\frac{5}{8}$	..	$\frac{11}{4}$	1.133
$\frac{5}{16}$	$\frac{1}{4}$	..	24	..	..	3	$6\frac{1}{2}$	$\frac{5}{8}$	.245	$3\frac{5}{8}$	..	$\frac{11}{4}$	1.128
$\frac{1}{4}$	$\frac{3}{8}$	20	..	..	..	3	$8\frac{3}{4}$	$\frac{5}{8}$	.180	$4\frac{17}{32}$	..	$\frac{17}{8}$	1.785
$\frac{1}{4}$	$\frac{3}{8}$	..	28	..	..	3	$8\frac{3}{4}$	$\frac{5}{8}$	.194	$4\frac{1}{2}$	..	$\frac{17}{8}$	1.778
$\frac{5}{16}$	$\frac{3}{8}$	18	..	..	..	3	$8\frac{3}{4}$	$\frac{3}{4}$	.235	$4\frac{15}{32}$	..	$\frac{17}{8}$	1.757
$\frac{5}{16}$	$\frac{3}{8}$	..	24	..	..	3	$8\frac{3}{4}$	$\frac{3}{4}$	.245	$4\frac{1}{16}$	..	$\frac{17}{8}$	1.752
$\frac{3}{8}$	$\frac{3}{8}$	16	..	..	..	3	$8\frac{3}{4}$	$\frac{13}{16}$	.289	$4\frac{13}{32}$	..	$\frac{17}{8}$	1.730
$\frac{3}{8}$	$\frac{3}{8}$	..	24	..	..	3	$8\frac{3}{4}$	$\frac{3}{4}$	.289	$4\frac{3}{8}$	.321	$\frac{17}{8}$	1.723
$\frac{3}{8}$	$\frac{1}{2}$	16	..	..	..	3	12	$\frac{13}{16}$	.289	$5\frac{29}{32}$	..	$2\frac{1}{2}$	2.355
$\frac{7}{16}$	$\frac{1}{2}$	..	24	..	..	3	12	$\frac{3}{4}$	.289	$5\frac{7}{8}$	.321	$2\frac{1}{2}$	2.348
$\frac{7}{16}$	$\frac{1}{2}$	14	..	..	..	3	12	$1\frac{3}{16}$	.340	$6\frac{3}{32}$	..	$2\frac{1}{2}$	2.330
$\frac{7}{16}$	$\frac{1}{2}$	..	20	..	..	3	12	$1\frac{1}{16}$	.340	$6\frac{1}{16}$	.373	$2\frac{1}{2}$	2.330
$\frac{1}{2}$	$\frac{1}{2}$	13	3	12	$1\frac{5}{16}$.395	$6\frac{1}{16}$..	$2\frac{1}{2}$	2.302
$\frac{1}{2}$	$\frac{1}{2}$..	20	3	12	$1\frac{1}{16}$.395	$6\frac{1}{32}$.435	$2\frac{1}{2}$	2.302

(Concluded on following page)

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"GREENFIELD" TOOLS

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TABLE 313—Bent Shank Tapper Taps

Fractional Sizes
GENERAL DIMENSIONS—Concluded

Diam. of Tap Inches	Size of Mach. In.	Threads per Inch				No. of Flutes	Dimensions—Inches						
		NC	NF	NS	SB		A	B	D	F	G	R	r
$\frac{9}{16}$	$\frac{5}{8}$	12	..	..	..	3	15	$1\frac{7}{16}$	.449	$7\frac{9}{32}$	..	$3\frac{3}{4}$	3.525
$\frac{9}{16}$	$\frac{5}{8}$	..	18	..	..	3	15	$1\frac{5}{16}$	.449	$7\frac{1}{4}$	.490	$3\frac{3}{4}$	3.525
$\frac{5}{8}$	$\frac{5}{8}$	11	..	..	..	3	15	$1\frac{5}{8}$	.502	$7\frac{1}{4}$	..	$3\frac{3}{4}$	3.499
$\frac{5}{8}$	$\frac{5}{8}$	..	18	..	..	3	15	$1\frac{5}{16}$	.502	$7\frac{1}{4}$	.553	$3\frac{3}{4}$	3.499
$\frac{3}{4}$	$\frac{5}{8}$	*10	..	..	..	3	15	$1\frac{13}{16}$	.605	$7\frac{3}{16}$	..	$3\frac{3}{4}$	3.447
$\frac{3}{4}$	$\frac{5}{8}$	..	16	..	..	3	15	$1\frac{5}{8}$	.605	$7\frac{3}{16}$	.669	$3\frac{3}{4}$	3.447
$\frac{3}{4}$	$\frac{7}{8}$	10	..	..	..	3	$18\frac{7}{16}$	$1\frac{13}{16}$	.605	$8\frac{1}{2}$	..	$4\frac{1}{2}$	4.197
$\frac{3}{4}$	$\frac{7}{8}$	..	16	..	..	3	$18\frac{7}{16}$	$1\frac{5}{8}$	.605	$8\frac{1}{2}$	.669	$4\frac{1}{2}$	4.197
$\frac{7}{8}$	$\frac{7}{8}$	9	..	..	..	3	$18\frac{7}{16}$	$1\frac{15}{16}$	.716	$8\frac{7}{16}$	..	$4\frac{1}{2}$	4.142
$\frac{7}{8}$	$\frac{7}{8}$	..	14	..	..	3	$18\frac{7}{16}$	$1\frac{3}{4}$	.716	$8\frac{7}{16}$	.782	$4\frac{1}{2}$	4.142
1	$\frac{7}{8}$	8	..	..	..	3	$18\frac{7}{16}$	$2\frac{3}{16}$	.823	$8\frac{13}{32}$	..	$4\frac{1}{2}$	4.088
1	$\frac{7}{8}$	..	14	..	..	3	$18\frac{7}{16}$	$1\frac{3}{4}$	.823	$8\frac{13}{32}$	.907	$4\frac{1}{2}$	4.088

*Recommended only for thin nuts.

TOLERANCES

Element	Range Inches	Direction	Tolerance	
			Cut Thread	Ground Thread
Length Overall—A	$\frac{1}{8}$ and $\frac{3}{16}$ $\frac{1}{4}$ to 1 incl.	Plus Plus	$\frac{1}{16}"$ $\frac{1}{8}"$	$\frac{1}{16}"$ $\frac{1}{8}"$
Length of Thread—B	$\frac{1}{8}$ to $\frac{1}{2}$ incl.	Plus or Minus	$\frac{1}{16}"$	$\frac{1}{16}"$
Diameter of Shank—D	$\frac{9}{16}$ to 1 incl.	Plus or Minus	$\frac{3}{32}"$	$\frac{3}{32}"$
	$\frac{1}{8}$ to $\frac{1}{2}$ incl.	Minus Minus	.005" .006"	.005" .006"

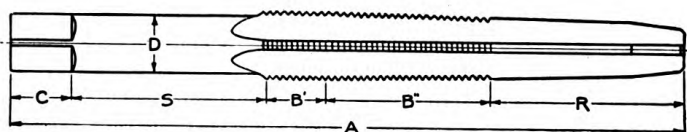
FORMULAE—(Approximate)

Diameter of Shank:	National Coarse Series	= $\frac{5}{8}"$ and under = Basic Root Diameter minus .005".
	National Fine Series	= $\frac{3}{4}"$ and over = Basic Root Diameter minus .010" (to nearest .001").
		= For $\frac{1}{4}"$ and $\frac{5}{16}"$ sizes only, 95% of Basic Root Diameter. $\frac{3}{8}"$ and larger, same shank diameter as National Coarse tap of corresponding size.
Diameter of Nut Guide	National Special Series	= Basic Root Diameter.
	Stove Bolt	= Basic Root Diameter + .003".
	National Coarse Series	= None.
	National Fine Series	= None for $\frac{1}{4}"$ and $\frac{5}{16}"$ sizes. $\frac{3}{8}"$ and larger, Basic Root Diameter to nearest .001".

NOTES: All taps up to $\frac{3}{8}"$ inclusive have external center on thread end; sizes $\frac{7}{16}$ inch and larger have internal center in thread end.
For standard thread limits and tolerances see Tables 325, 332, 336 and 337.

★ "GREENFIELD" TOOLS ★

TABLE 314
Staybolt Taps



GENERAL DIMENSIONS

Diam. of Tap Inches	Dimensions—Inches							
	Length Over-all A	Length of Straight Thread B'	Length of Taper Thread B"	Length of Square C	Diam. of Shank D	Size of Square E	Length of Reamer R	Length of Shank S
$\frac{7}{8}$	24	2	6	1	.750	$\frac{5}{8}$	7	8
$\frac{7}{8}$	27	2	$6\frac{1}{2}$	1	.750	$\frac{5}{8}$	$7\frac{1}{2}$	10
$\frac{15}{16}$	24	2	6	1	.812	$\frac{5}{8}$	7	8
$\frac{15}{16}$	27	2	$6\frac{1}{2}$	1	.812	$\frac{5}{8}$	$7\frac{1}{2}$	10
1	24	2	6	1	.875	$\frac{5}{8}$	7	8
1	27	2	$6\frac{1}{2}$	1	.875	$\frac{5}{8}$	$7\frac{1}{2}$	10
$1\frac{1}{16}$	24	2	6	1	.937	$\frac{5}{8}$	7	8
$1\frac{1}{16}$	27	2	$6\frac{1}{2}$	1	.937	$\frac{5}{8}$	$7\frac{1}{2}$	10
$1\frac{1}{8}$	24	2	6	1	1.000	$\frac{3}{4}$	7	8
$1\frac{1}{8}$	27	2	$6\frac{1}{2}$	1	1.000	$\frac{3}{4}$	$7\frac{1}{2}$	10
$1\frac{3}{16}$	24	2	6	1	1.062	$\frac{3}{4}$	7	8
$1\frac{3}{16}$	27	2	$6\frac{1}{2}$	1	1.062	$\frac{3}{4}$	$7\frac{1}{2}$	10
$1\frac{1}{4}$	24	2	6	1	1.125	$\frac{3}{4}$	7	8
$1\frac{1}{4}$	27	2	$6\frac{1}{2}$	1	1.125	$\frac{3}{4}$	$7\frac{1}{2}$	10
$1\frac{5}{16}$	24	2	6	1	1.187	$\frac{3}{4}$	7	8
$1\frac{5}{16}$	27	2	$6\frac{1}{2}$	1	1.187	$\frac{3}{4}$	$7\frac{1}{2}$	10
$1\frac{3}{8}$	24	2	6	1	1.250	1	7	8
$1\frac{3}{8}$	27	2	$6\frac{1}{2}$	1	1.250	1	$7\frac{1}{2}$	10
$1\frac{7}{16}$	24	2	6	1	1.312	1	7	8
$1\frac{7}{16}$	27	2	$6\frac{1}{2}$	1	1.312	1	$7\frac{1}{2}$	10
$1\frac{1}{2}$	24	2	6	1	1.375	1	7	8
$1\frac{1}{2}$	27	2	$6\frac{1}{2}$	1	1.375	1	$7\frac{1}{2}$	10

TOLERANCES

Element	Range, Inches	Direction	Tolerance, Inches
Length Overall—A	$\frac{7}{8}$ to $1\frac{1}{2}$ incl.	Plus or Minus	$\frac{3}{16}$
Lengths B', B" or R (not accumulative)	$\frac{7}{8}$ to $1\frac{1}{2}$ incl.	Plus or Minus	$\frac{1}{8}$
Length of Square—C	$\frac{7}{8}$ to $1\frac{1}{2}$ incl.	Plus or Minus	$\frac{1}{16}$
Diameter of Shank—D	$\frac{7}{8}$ to $1\frac{1}{2}$ incl.	Minus	.007
Size of Square—E	$\frac{7}{8}$ to $1\frac{1}{2}$ incl.	Minus	.008

NOTES

All taps have internal center in reamer end.
For standard thread dimensions and limits see Table 333.



TABLE 325
Fractional Size Taps
 Cut Thread—American National Form

Size	Threads per Inch			Major Diameter			Pitch Diameter		
	NC	NF	NS	Basic	Minimum	Maximum	Basic	Minimum	Maximum
$\frac{1}{16}$	64	.0625	.0635	.0650	.0524	.0526	.0536
$\frac{5}{64}$	60	.0781	.0792	.0807	.0673	.0675	.0685
$\frac{3}{32}$	48	.0938	.0951	.0966	.0803	.0805	.0815
$\frac{3}{32}$	50	.0938	.0951	.0966	.0808	.0810	.0820
$\frac{7}{64}$	48	.1094	.1107	.1127	.0959	.0961	.0976
$\frac{1}{8}$	40	.1250	.1266	.1286	.1088	.1090	.1105
$\frac{9}{64}$	40	.1406	.1422	.1442	.1244	.1246	.1261
$\frac{5}{32}$	32	.1563	.1585	.1605	.1360	.1365	.1380
$\frac{5}{32}$	36	.1563	.1580	.1600	.1382	.1384	.1399
$\frac{3}{16}$	24	.1875	.1903	.1923	.1604	.1609	.1624
$\frac{3}{16}$	32	.1875	.1897	.1917	.1672	.1677	.1692
$\frac{7}{32}$	24	.2188	.2216	.2236	.1917	.1922	.1937
$\frac{7}{32}$	32	.2188	.2210	.2230	.1985	.1990	.2005
$\frac{1}{4}$	20	..	..	.2500	.2532	.2557	.2175	.2180	.2200
$\frac{1}{4}$	24	.2500	.2528	.2553	.2229	.2234	.2254
$\frac{1}{4}$	27	.2500	.2525	.2550	.2259	.2264	.2284
$\frac{1}{4}$..	28	..	.2500	.2524	.2549	.2268	.2273	.2288
$\frac{1}{4}$	32	.2500	.2522	.2547	.2297	.2302	.2317
$\frac{5}{16}$	18	..	..	.3125	.3160	.3185	.2764	.2769	.2789
$\frac{5}{16}$	20	.3125	.3157	.3182	.2800	.2805	.2825
$\frac{5}{16}$..	24	..	.3125	.3153	.3178	.2854	.2859	.2874
$\frac{5}{16}$	27	.3125	.3150	.3175	.2884	.2889	.2904
$\frac{5}{16}$	32	.3125	.3147	.3172	.2922	.2927	.2942
$\frac{3}{8}$	16	..	..	.3750	.3789	.3814	.3344	.3349	.3369
$\frac{3}{8}$	20	.3750	.3782	.3807	.3425	.3430	.3450
$\frac{3}{8}$..	24	..	.3750	.3778	.3803	.3479	.3484	.3499
$\frac{3}{8}$	27	.3750	.3775	.3800	.3509	.3514	.3529
$\frac{7}{16}$	14	..	..	.4375	.4419	.4449	.3911	.3916	.3941
$\frac{7}{16}$..	20	..	.4375	.4407	.4437	.4050	.4055	.4075
$\frac{7}{16}$	24	.4375	.4403	.4433	.4104	.4109	.4129
$\frac{7}{16}$	27	.4375	.4400	.4430	.4134	.4139	.4159
$\frac{1}{2}$	12	.5000	.5050	.5080	.4459	.4464	.4489
$\frac{1}{2}$	13	..	..	.5000	.5047	.5077	.4500	.4505	.4530
$\frac{1}{2}$..	20	..	.5000	.5032	.5062	.4675	.4680	.4700
$\frac{1}{2}$	24	.5000	.5028	.5058	.4729	.4734	.4754
$\frac{1}{2}$	27	.5000	.5025	.5055	.4759	.4764	.4784
$\frac{9}{16}$	12	..	..	.5625	.5675	.5705	.5084	.5089	.5114
$\frac{9}{16}$..	18	..	.5625	.5660	.5690	.5264	.5269	.5289
$\frac{9}{16}$	27	.5625	.5650	.5680	.5384	.5389	.5409
$\frac{5}{8}$	116250	.6304	.6334	.5660	.5665	.5690

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★ "GREENFIELD" TOOLS ★

TABLE 325—Fractional Size Taps

(Continued)

Cut Thread—American National Form

THREAD LIMITS

Size	Threads per Inch			Major Diameter			Pitch Diameter		
	NC	NF	NS	Basic	Minimum	Maximum	Basic	Minimum	Maximum
$\frac{5}{8}$	..	..	12	.6250	.6300	.6330	.5709	.5714	.5739
$\frac{5}{8}$	..	18	..	.6250	.6285	.6315	.5889	.5894	.5914
$\frac{5}{8}$	..	..	27	.6250	.6275	.6305	.6009	.6014	.6034
$\frac{11}{16}$	..	..	11	.6875	.6929	.6969	.6285	.6290	.6320
$\frac{11}{16}$	..	..	16	.6875	.6914	.6954	.6469	.6474	.6499
$\frac{3}{4}$	10	..	..	.7500	.7559	.7599	.6850	.6855	.6885
$\frac{3}{4}$	..	..	12	.7500	.7550	.7590	.6959	.6964	.6994
$\frac{3}{4}$	..	16	..	.7500	.7539	.7579	.7094	.7099	.7124
$\frac{3}{4}$	..	..	27	.7500	.7525	.7565	.7259	.7264	.7289
$\frac{7}{8}$	9	..	..	.8750	.8820	.8860	.8028	.8038	.8068
$\frac{7}{8}$	..	..	12	.8750	.8805	.8845	.8209	.8219	.8249
$\frac{7}{8}$	..	14	..	.8750	.8799	.8839	.8286	.8296	.8321
$\frac{7}{8}$	..	..	18	.8750	.8790	.8830	.8389	.8399	.8424
$\frac{7}{8}$	..	..	27	.8750	.8780	.8820	.8509	.8519	.8544
1	8	..	..	1.0000	1.0078	1.0118	.9188	.9198	.9228
1	..	..	12	1.0000	1.0055	1.0095	.9459	.9469	.9499
1	..	14	..	1.0000	1.0049	1.0089	.9536	.9546	.9571
1	..	..	27	1.0000	1.0030	1.0070	.9759	.9769	.9794
$1\frac{1}{8}$	7	..	..	1.1250	1.1337	1.1382	1.0322	1.0332	1.0367
$1\frac{1}{8}$	..	..	12	1.1250	1.1305	1.1350	1.0709	1.0719	1.0749
$1\frac{1}{8}$	7	..	..	1.2500	1.2587	1.2632	1.1572	1.1582	1.1617
$1\frac{1}{4}$	..	..	12	1.2500	1.2555	1.2600	1.1959	1.1969	1.1999
$1\frac{3}{8}$	6	..	..	1.3750	1.3850	1.3895	1.2667	1.2677	1.2712
$1\frac{3}{8}$	..	..	12	1.3750	1.3805	1.3850	1.3209	1.3219	1.3249
$1\frac{1}{2}$	6	..	..	1.5000	1.5100	1.5145	1.3917	1.3927	1.3962
$1\frac{1}{2}$	..	..	12	1.5000	1.5055	1.5100	1.4459	1.4469	1.4499
$1\frac{5}{8}$	..	..	$5\frac{1}{2}$	1.6250	1.6344	1.6399	1.5069	1.5084	1.5124
$1\frac{3}{4}$	5	..	..	1.7500	1.7602	1.7657	1.6201	1.6216	1.6256
$1\frac{7}{8}$	..	..	5	1.8750	1.8852	1.8907	1.7451	1.7466	1.7506
2	$4\frac{1}{2}$	..	..	2.0000	2.0111	2.0166	1.8557	1.8572	1.8612
$2\frac{1}{8}$	..	..	$4\frac{1}{2}$	2.1250	2.1361	2.1421	1.9807	1.9822	1.9867
$2\frac{1}{4}$	$4\frac{1}{2}$	..	..	2.2500	2.2611	2.2671	2.1057	2.1072	2.1117
$2\frac{3}{8}$	..	..	4	2.3750	2.3878	2.3938	2.2126	2.2146	2.2191
$2\frac{1}{2}$	4	..	..	2.5000	2.5128	2.5188	2.3376	2.3396	2.3441
$2\frac{5}{8}$	..	..	4	2.6250	2.6378	2.6448	2.4626	2.4646	2.4696
$2\frac{3}{4}$	4	..	..	2.7500	2.7628	2.7698	2.5876	2.5896	2.5946
$2\frac{7}{8}$	..	..	$3\frac{1}{2}$	2.8750	2.8894	2.8964	2.6894	2.6914	2.6964
3	4	..	..	3.0000	3.0133	3.0203	2.8376	2.8401	2.8456
$3\frac{1}{4}$	4	..	..	3.2500	3.2633	3.2703	3.0876	3.0901	3.0956
$3\frac{1}{2}$	4	..	..	3.5000	3.5133	3.5203	3.3376	3.3401	3.3456
$3\frac{3}{4}$	4	3.7500	3.7633	3.7703	3.5876	3.5901	3.5956
4	4	4.0000	4.0133	4.0203	3.8376	3.8401	3.8456

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TABLE 325
(Concluded)

Fractional Size Taps

Cut Thread—American National Form

LEAD TOLERANCE

A MAXIMUM lead error of plus or minus .003" in one inch of thread is permitted.

ANGLE TOLERANCE

Threads per Inch	Error in Half Angle	Error in Full Angle
4 and coarser	30' Plus or Minus	45'
4½ to 5½ incl.	35' Plus or Minus	53'
6 to 9 incl.	40' Plus or Minus	60'
10 to 28 incl.	45' Plus or Minus	68'
30 to 64 incl.	60' Plus or Minus	90'

FORMULAE

Minimum Major Diameter = Basic plus (B + C)

Maximum Major Diameter = Minimum plus A

Minimum Pitch Diameter = Basic plus B

Maximum Pitch Diameter = Minimum plus D

In the above formulae:

A = Major diameter tolerance

B = Amount minimum pitch diameter is over basic

C = A constant to add:

20% of the theoretical truncation for 2 to 5½ threads per inch

25% for 6 to 64 threads per inch

D = Pitch diameter tolerance

For values of A, B, C and D see Table 330.

NOTES

Pitches coarser than NF take NC tolerances. Pitches finer than NF take tolerances as shown in Table 330.

For Staybolt Taps see Table 333.



TABLE 326—Fractional Size Taps

Commercial Ground Thread—American National Form

THREAD LIMITS

Size	Threads per Inch			Major Diameter			Pitch Diameter		
	NC	NF	NS	Basic	Minimum	Maximum	Basic	Minimum	Maximum
1/4	20	..	..	.2500	.2540	.2550	.2175	.2180	.2190
1/4	..	28	..	.2500	.2525	.2535	.2268	.2273	.2283
5/16	18	..	..	.3125	.3170	.3180	.2764	.2769	.2779
5/16	..	24	..	.3125	.3155	.3165	.2854	.2859	.2869
3/8	16	..	..	.3750	.3800	.3810	.3344	.3349	.3359
3/8	..	24	..	.3750	.3780	.3790	.3479	.3484	.3494
7/16	14	..	..	.4375	.4435	.4445	.3911	.3916	.3926
7/16	..	20	..	.4375	.4415	.4425	.4050	.4055	.4065
1/2	13	..	..	.5000	.5065	.5075	.4500	.4505	.4515
1/2	..	20	..	.5000	.5040	.5050	.4675	.4680	.4690
9/16	12	..	..	.5625	.5690	.5700	.5084	.5089	.5099
9/16	..	18	..	.5625	.5670	.5680	.5264	.5269	.5279
5/8	11	..	..	.6250	.6320	.6330	.5660	.5665	.5676
5/8	..	18	..	.6250	.6295	.6305	.5889	.5894	.5904
11/16	..	..	11	.6875	.6945	.6955	.6285	.6290	.6301
11/16	..	..	16	.6875	.6925	.6935	.6469	.6474	.6484
3/4	10	..	..	.7500	.7575	.7590	.6850	.6855	.6866
3/4	..	16	..	.7500	.7550	.7560	.7094	.7099	.7109
7/8	9	..	..	.8750	.8835	.8850	.8028	.8038	.8050
7/8	..	14	..	.8750	.8810	.8820	.8286	.8296	.8306
7/8	..	..	18	.8750	.8795	.8805	.8389	.8399	.8409
1	8	..	..	1.0000	1.0095	1.0110	.9188	.9198	.9212
1	..	14	..	1.0000	1.0060	1.0070	.9536	.9546	.9556
1 1/8	7	..	..	1.1250	1.1350	1.1370	1.0322	1.0332	1.0347
1 1/8	..	12	..	1.1250	1.1315	1.1325	1.0709	1.0719	1.0729
1 1/4	7	..	..	1.2500	1.2600	1.2620	1.1572	1.1582	1.1597
1 1/4	..	12	..	1.2500	1.2565	1.2575	1.1959	1.1969	1.1979
1 3/8	6	..	..	1.3750	1.3870	1.3890	1.2667	1.2677	1.2695
1 3/8	..	12	..	1.3750	1.3815	1.3825	1.3209	1.3219	1.3229
1 1/2	6	..	..	1.5000	1.5120	1.5140	1.3917	1.3927	1.3945
1 1/2	..	12	..	1.5000	1.5065	1.5075	1.4459	1.4469	1.4479
1 5/8	..	..	5 1/2	1.6250	1.6385	1.6410	1.5069	1.5084	1.5104
1 3/4	5	..	..	1.7500	1.7635	1.7660	1.6201	1.6216	1.6236
1 7/8	..	..	5	1.8750	1.8885	1.8910	1.7451	1.7466	1.7486
2	4 1/2	..	..	2.0000	2.0145	2.0170	1.8557	1.8572	1.8592
2 1/4	4 1/2	..	..	2.2500	2.2645	2.2670	2.1057	2.1072	2.1092
2 1/2	4	..	..	2.5000	2.5165	2.5190	2.3376	2.3396	2.3416
2 3/4	4	..	..	2.7500	2.7665	2.7690	2.5876	2.5896	2.5916
3	4	..	..	3.0000	3.0165	3.0190	2.8376	2.8396	2.8416
3 1/4	4	..	..	3.2500	3.2665	3.2690	3.0876	3.0896	3.0916
3 1/2	4	..	..	3.5000	3.5165	3.5190	3.3376	3.3396	3.3416
3 3/4	4	3.7500	3.7665	3.7690	3.5876	3.5896	3.5916
4	4	4.0000	4.0165	4.0190	3.8376	3.8396	3.8416

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TABLE 326
(Concluded)

Fractional Size Taps

Commercial Ground Thread—American National Form

LEAD TOLERANCE

A MAXIMUM lead error of plus or minus .0005" in one inch of thread is permitted.

ANGLE TOLERANCE

Threads per Inch	Error in Half Angle
4 to 5½ incl.	20' Plus or Minus
6 to 9 incl.	25' Plus or Minus
10 to 28 incl.	30' Plus or Minus

FORMULAE

Maximum Major Diameter = Basic plus C
 Minimum Major Diameter = Maximum minus A
 Maximum Pitch Diameter = Minimum plus D
 Minimum Pitch Diameter = Basic plus B

In the above formulae:—

- A = Major diameter tolerance
 - B = Amount over basic for minimum pitch diameter
 - C = A constant to add:
 - 35% of the theoretical truncation for 4 to 5 threads per inch
 - 40% for 5½ to 12 threads per inch
 - 45% for 13 to 48 threads per inch
 - To nearest .0005" for 8 or more threads per inch and to nearest .001" for less than 8 threads per inch.
 - D = Pitch diameter tolerance
- For values of A, B, C and D see Table 331.

NOTES

All fractional size ground thread taps are regularly made to the above limits and tolerances unless otherwise specified.

For Precision ground thread pitch diameter limits for hand taps see Table 327.



TABLE 327
Fractional Size Taps
 Precision Ground Thread—American National Form
THREAD LIMITS

Size	Threads per Inch		Major Diameter		Basic Pitch Diam.	Pitch Diameter Limits			
						1 Limit		2 Limit	
	NC	NF	Min.	Max.		01 Limit	1 Limit	2 Limit	
						Min. 01	Max. 01 Min. 1	Max. 1 Min. 2	Max. 2
1/4	20	..	.2540	.2550	.2175	.2170	.2175	.2180	.2185
1/4	..	28	.2525	.2535	.2268	.....	.2268	.2273	.2278
5/16	18	..	.3170	.3180	.2764	.2759	.2764	.2769	.2774
5/16	..	24	.3155	.3165	.2854	.....	.2854	.2859	.2864
3/8	16	..	.3800	.3810	.3344	.3339	.3344	.3349	.3354
3/8	..	24	.3780	.3790	.3479	.....	.3479	.3484	.3489
7/16	14	..	.4435	.4445	.3911	.3906	.3911	.3916	.3921
7/16	..	20	.4415	.4425	.4050	.....	.4050	.4055	.4060
1/2	13	..	.5065	.5075	.4500	.4495	.4500	.4505	.4510
1/2	..	20	.5040	.5050	.4675	.....	.4675	.4680	.4685
9/16	12	..	.5690	.5700	.5084	.....	.5084	.5089	.5094
9/16	..	18	.5670	.5680	.5264	.....	.5264	.5269	.5274
5/8	11	..	.6320	.6330	.5660	.....	.5660	.5665	.5670
5/8	..	18	.6295	.6305	.5889	.....	.5889	.5894	.5899
3/4	10	..	.7575	.7590	.6850	.....	.6850	.6855	.6860
3/4	..	16	.7550	.7560	.7094	.....	.7094	.7099	.7104
7/8	9	..	.8835	.8850	.8028	.....	.8028	.8033	.8038
7/8	..	14	.8810	.8820	.8286	.....	.8286	.8291	.8296
1	8	..	1.0095	1.0110	.9188	.....	.9188	.9193	.9198
1	..	14	1.0060	1.0070	.9536	.....	.9536	.9541	.9546

LEAD TOLERANCE

A maximum lead error of plus or minus .0005" in one inch of thread is permitted.

ANGLE TOLERANCE

Threads per Inch	Error in Half Angle
8 to 9 Incl.	25' plus or minus
10 to 28 Incl.	30' plus or minus

FORMULAE

Major Diameter is the same as for commercial ground taps.

Pitch Diameter 01 Limit = Basic to basic minus .0005"

Pitch Diameter 1 Limit = Basic to basic plus .0005"

Pitch Diameter 2 Limit = Basic plus .0005" to basic plus .0010"

NOTES

Precision ground thread hand taps not listed in table above are special.
 For commercial ground thread limits see Table 326.



TABLE 328
Machine Screw Taps
Cut Thread—American National Form

THREAD LIMITS									
Screw Gage No.	Threads per Inch			Major Diameter			Pitch Diameter		
	NC	NF	NS	Basic	Mini- mum	Maxi- mum	Basic	Mini- mum	Maxi- mum
0	..	80	..	.0600	.0609	.0624	.0519	.0521	.0531
1	..	..	56	.0730	.0742	.0757	.0614	.0616	.0626
1	64	..	..	.0730	.0740	.0755	.0629	.0631	.0641
1	..	72	..	.0730	.0740	.0755	.0640	.0642	.0652
2	56	..	..	.0860	.0872	.0887	.0744	.0746	.0756
2	..	64	..	.0860	.0870	.0885	.0759	.0761	.0771
3	48	..	..	.0990	.1003	.1018	.0855	.0857	.0867
3	..	56	..	.0990	.1002	.1017	.0874	.0876	.0886
4	..	..	32	.1120	.1142	.1162	.0917	.0922	.0937
4	..	..	36	.1120	.1137	.1157	.0940	.0942	.0957
4	40	..	..	.1120	.1136	.1156	.0958	.0960	.0975
4	..	48	..	.1120	.1133	.1153	.0985	.0987	.1002
5	..	..	36	.1250	.1267	.1287	.1070	.1072	.1087
5	40	..	..	.1250	.1266	.1286	.1088	.1090	.1105
5	..	44	..	.1250	.1264	.1284	.1102	.1104	.1119
6	32	..	..	.1380	.1402	.1422	.1177	.1182	.1197
6	..	..	36	.1380	.1397	.1417	.1200	.1202	.1217
6	..	40	..	.1380	.1396	.1416	.1218	.1220	.1235
7	..	..	30	.1510	.1533	.1553	.1294	.1299	.1314
7	..	..	32	.1510	.1532	.1552	.1307	.1312	.1327
7	..	..	36	.1510	.1527	.1547	.1330	.1332	.1347
8	..	..	30	.1640	.1663	.1683	.1423	.1428	.1443
8	32	..	..	.1640	.1662	.1682	.1437	.1442	.1457
8	..	36	..	.1640	.1657	.1677	.1460	.1462	.1477
8	..	..	40	.1640	.1656	.1676	.1478	.1480	.1495
9	..	..	24	.1770	.1798	.1818	.1499	.1504	.1519
9	..	..	30	.1770	.1793	.1813	.1553	.1558	.1573
9	..	..	32	.1770	.1792	.1812	.1567	.1572	.1587
10	24	..	..	.1900	.1928	.1948	.1629	.1634	.1649
10	..	..	28	.1900	.1924	.1944	.1668	.1673	.1688
10	..	..	30	.1900	.1923	.1943	.1684	.1689	.1704
10	..	32	..	.1900	.1922	.1942	.1697	.1702	.1717
12	24	..	..	.2160	.2188	.2208	.1889	.1894	.1909
12	..	28	..	.2160	.2184	.2204	.1928	.1933	.1948
12	32	.2160	.2182	.2202	.1957	.1962	.1977
14	20	.2420	.2452	.2477	.2095	.2100	.2120
14	24	.2420	.2448	.2473	.2149	.2154	.2174

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TABLE 328

(Concluded)

Machine Screw Taps

Cut Thread—American National Form

THREAD LIMITS

Screw Gage Num- ber	Threads per Inch			Major Diameter			Pitch Diameter		
	NC	NF	NS	Basic	Mini- mum	Maxi- mum	Basic	Mini- mum	Maxi- mum
16	18	.2680	.2715	.2740	.2319	.2324	.2344
16	20	.2680	.2712	.2737	.2355	.2360	.2380
16	22	.2680	.2710	.2735	.2385	.2390	.2410
18	18	.2940	.2975	.3000	.2579	.2584	.2604
18	20	.2940	.2972	.2997	.2615	.2620	.2640
20	16	.3200	.3239	.3264	.2794	.2799	.2819
20	18	.3200	.3235	.3260	.2839	.2844	.2864
20	20	.3200	.3232	.3257	.2875	.2880	.2900

LEAD TOLERANCE

A maximum lead error of plus or minus .003" in one inch of thread is permitted.

ANGLE TOLERANCE

Threads per Inch	Error in Half Angle	Error in Full Angle
16 to 28 inclusive	45' Plus or Minus	68'
30 and finer	60' Plus or Minus	90'

FORMULAE

Minimum Major Diameter = Basic plus (B + C)

Maximum Major Diameter = Minimum plus A

Minimum Pitch Diameter = Basic plus B

Maximum Pitch Diameter = Minimum plus D

In the above formulae:

A = Major diameter tolerance

B = Amount minimum pitch diameter is over basic

C = A constant to add:

25% of the theoretical truncation for 16 to 80 threads per inch

D = Pitch diameter tolerance

For values of A, B, C and D see Table 330.



TABLE 329
Machine Screw Taps
 Commercial Ground Thread—American National Form
THREAD LIMITS

Screw Gage No.	Threads per Inch			Major Diameter			Pitch Diameter		
	NC	NF	NS	Basic	Mini- mum	Maxi- mum	Basic	Mini- mum	Maxi- mum
3	48	..	..	.0990	.1000	.1010	.0855	.0857	.0867
3	..	56	..	.0990	.0995	.1005	.0874	.0876	.0886
4	..	..	36	.1120	.1135	.1145	.0940	.0942	.0952
4	40	..	..	.1120	.1135	.1145	.0958	.0960	.0970
4	..	48	..	.1120	.1130	.1140	.0985	.0987	.0997
5	40	..	..	.1250	.1265	.1275	.1088	.1090	.1100
5	..	44	..	.1250	.1260	.1270	.1102	.1104	.1114
6	32	..	..	.1380	.1400	.1410	.1177	.1182	.1192
6	..	40	..	.1380	.1395	.1405	.1218	.1220	.1230
8	32	..	..	.1640	.1660	.1670	.1437	.1442	.1452
8	..	36	..	.1640	.1655	.1665	.1460	.1462	.1472
10	24	..	..	.1900	.1930	.1940	.1629	.1634	.1644
10	..	32	..	.1900	.1920	.1930	.1697	.1702	.1712
12	24	..	..	.2160	.2190	.2200	.1889	.1894	.1904
12	..	28	..	.2160	.2185	.2195	.1928	.1933	.1943
14	..	..	20	.2420	.2460	.2470	.2095	.2100	.2110
14	..	..	24	.2420	.2450	.2460	.2149	.2154	.2164

LEAD TOLERANCE

A maximum lead error of plus or minus .0005" in one inch of thread is permitted.

ANGLE TOLERANCE

20 to 56 threads per inch incl. = 30' plus or minus in 1/2 angle.

FORMULAE

Maximum Major Diameter = Basic plus C

Minimum Major Diameter = Maximum minus A

Maximum Pitch Diameter = Minimum plus D

Minimum Pitch Diameter = Basic plus B

In the above formulae:

A = Major diameter tolerance

B = Amount over basic for minimum pitch diameter

C = A constant to add:

45% of the theoretical truncation to nearest .0005"

D = Pitch diameter tolerance

For values of A, B, C and D see Table 331.

NOTE

All ground thread machine screw taps are regularly made to the above limits and tolerances unless otherwise specified.

★ "GREENFIELD" TOOLS ★

TABLE 330—Special Taps

Cut Thread—American National Form

GENERAL: The following tables and formulae are used in determining the limits and tolerances for cut thread taps having special diameter or special pitch or both.

LEAD TOLERANCE: A maximum lead error of plus or minus .003" in one inch of thread is permitted

ANGLE TOLERANCE

Threads per Inch	Error in Half Angle	Error in Full Angle
4 and coarser	30' Plus or Minus	45'
4½ to 5½ incl.	35' Plus or Minus	53'
6 to 9 incl.	40' Plus or Minus	60'
10 to 28 incl.	45' Plus or Minus	68'
30 and finer	60' Plus or Minus	90'

FORMULAE

Min. Major Dia. = Basic plus (B+C) Min. Pitch Dia. = Basic plus B
 Max. Major Dia. = Min. plus A Max. Pitch Dia. = Min. plus D

A = Major diameter tolerance

B = Amount minimum pitch diameter is over basic

C = A constant to add:

20% of the theoretical truncation for 2 to 5½ threads per inch

25% for 6 to 80 threads per inch

D = Pitch diameter tolerance

VALUES FOR A, B AND D

Diameter of Tap, Inches	A	B		D	
		36 or More Threads per Inch	34 or Less Threads per Inch	Coarser than NF	*NF and Finer
0 to .099 incl.	.0015	.0002	.0005	.0010	.0010
.100 to .249 incl.	.0020	.0002	.0005	.0015	.0015
¼ to ⅜ incl.	.0025	.0005	.0005	.0020	.0015
Over ⅜ to ½ incl.	.0030	.0005	.0005	.0025	.0020
Over ½ to ¾ incl.	.0040	.0005	.0005	.0030	.0025
Over ¾ to 1 incl.	.0040	.0010	.0010	.0030	.0025
Over 1 to 1½ incl.	.0045	.0010	.0010	.0035	.0030
Over 1½ to 2 incl.	.0055	.0015	.0015	.0040	.0030
Over 2 to 2½ incl.	.0060	.0015	.0015	.0045	.0035
Over 2½ to 3 incl.	.0060	.0020	.0020	.0045	.0035
Over 3 to 4 incl.	.0070	.0020	.0020	.0050	.0035
Over 4 to 5 incl.	.0070	.0025	.0025	.0055	.0045

VALUES FOR C

Threads per Inch	Constant	Threads per Inch	Constant	Threads per Inch	Constant	Threads per Inch	Constant
2	.0217	7	.0077	18	.0030	36	.0015
2½	.0173	8	.0068	20	.0027	40	.0014
3	.0144	9	.0060	22	.0025	48	.0011
3½	.0124	10	.0054	24	.0023	50	.0011
4	.0108	11	.0049	26	.0021	56	.0010
4½	.0096	12	.0045	27	.0020	60	.0009
5	.0087	13	.0042	28	.0019	64	.0008
5½	.0079	14	.0039	30	.0018	72	.0008
6	.0090	16	.0034	32	.0017	80	.0007

For intermediate pitches use constant for next coarser pitch.

NOTE: *Taps over 1½" with 10 or more threads per inch have tolerances for NF and finer.

★ "GREENFIELD" TOOLS ★

TABLE 331—Special Taps

Commercial Ground Thread—American National Form

GENERAL: The following tables and formulae are used in determining the limits and tolerances for ground thread taps having special diameter or special pitch or both.

LEAD TOLERANCE: A maximum lead error of plus or minus .0005" in one inch of thread is permitted.

ANGLE TOLERANCE

Threads per inch	Error in Half Angle
4 to 5½ incl.	20' Plus or Minus
6 to 9 incl.	25' Plus or Minus
10 to 56 incl.	30' Plus or Minus

FORMULAE

Max. Major Dia. = Basic plus C
Min. Major Dia. = Max. minus A

Max. Pitch Dia. = Min. plus D
Min. Pitch Dia. = Basic plus B

In the above formulae: —

A = Major diameter tolerance

B = Amount over basic for minimum pitch diameter

C = A constant to add:

35% of the theoretical truncation for 4 to 5 threads per inch

40% for 5½ to 12 threads per inch

45% for 13 to 56 threads per inch

To nearest .0005" for 8 or more threads per inch and to nearest .001" for less than 8 threads per inch

D = Pitch diameter tolerance

VALUES FOR A, B, C AND D

Threads per Inch	A	B				C	D
		To ¾" incl.	Over ¾" to 1½" incl.	Over 1½" to 2¼" incl.	Over 2¼"		
56	.0010	.0002	.0010	.0015	.0020	.0015	.0010
48	.0010	.0002	.0010	.0015	.0020	.0020	.0010
44	.0010	.0002	.0010	.0015	.0020	.0020	.0010
40	.0010	.0002	.0010	.0015	.0020	.0025	.0010
36	.0010	.0002	.0010	.0015	.0020	.0025	.0010
32	.0010	.0005	.0010	.0015	.0020	.0030	.0010
28	.0010	.0005	.0010	.0015	.0020	.0035	.0010
24	.0010	.0005	.0010	.0015	.0020	.0040	.0010
20	.0010	.0005	.0010	.0015	.0020	.0050	.0010
18	.0010	.0005	.0010	.0015	.0020	.0055	.0010
16	.0010	.0005	.0010	.0015	.0020	.0060	.0010
14	.0010	.0005	.0010	.0015	.0020	.0070	.0010
13	.0010	.0005	.0010	.0015	.0020	.0075	.0010
12	.0010	.0005	.0010	.0015	.0020	.0075	.0010
11	.0010	.0005	.0010	.0015	.0020	.0080	.0011
10	.0015	.0005	.0010	.0015	.0020	.0090	.0011
9	.0015	....	.0010	.0015	.0020	.0100	.0012
8	.0015	....	.0010	.0015	.0020	.0110	.0014
7	.0020	....	.0010	.0015	.0020	.0120	.0015
6	.0020	....	.0010	.0015	.0020	.0140	.0018
5½	.0025	....	....	.0015	.0020	.0160	.0020
5	.0025	....	....	.0015	.0020	.0160	.0020
4½	.0025	....	....	.0015	.0020	.0170	.0020
4	.0025	....	....	.0015	.0020	.0190	.0020

For intermediate pitches use value for next coarser pitch.



TABLE 332—Stove Bolt Taps

Cut Thread—Manufacturers Standard

THREAD LIMITS

Size	Threads per Inch SB	Major Diameter			Pitch Diameter		
		Basic	Minimum	Maximum	Basic	Minimum	Maximum
$\frac{1}{8}$	32	.1250	.1280	.1310	.1080	.1110	.1130
$\frac{5}{32}$	28	.1630	.1660	.1690	.1440	.1470	.1490
$\frac{3}{16}$	24	.1950	.1980	.2010	.1730	.1760	.1780
$\frac{7}{32}$	22	.2220	.2255	.2285	.1980	.2015	.2035
$\frac{1}{4}$	18	.2500	.2525	.2555	.2240	.2275	.2295
$\frac{5}{16}$	18	.3125	.3150	.3180	.2764	.2779	.2804
$\frac{3}{8}$	16	.3750	.3780	.3810	.3344	.3359	.3384
$\frac{7}{16}$	14	.4375	.4400	.4440	.3911	.3926	.3956
$\frac{1}{2}$	13	.5000	.5030	.5070	.4500	.4515	.4545

LEAD TOLERANCE

A maximum lead error of plus or minus .003" in one inch of thread is permitted.

TABLE 333—Straight Boiler and Staybolt Taps

Cut Thread—American National Form

THREAD LIMITS

Size	Threads per Inch National Form	Major Diameter			Pitch Diameter		
		Basic	Minimum	Maximum	Basic	Minimum	Maximum
$\frac{1}{2}$	12	.5000	.5010	.5040	.4459	.4464	.4489
$\frac{9}{16}$	12	.5625	.5635	.5665	.5084	.5089	.5114
$\frac{5}{8}$	12	.6250	.6260	.6290	.5709	.5714	.5739
$\frac{11}{16}$	12	.6875	.6885	.6925	.6334	.6339	.6369
$\frac{3}{4}$	12	.7500	.7510	.7550	.6959	.6964	.6994
$\frac{13}{16}$	12	.8125	.8135	.8175	.7584	.7589	.7619
$\frac{7}{8}$	12	.8750	.8760	.8800	.8209	.8214	.8244
$\frac{15}{16}$	12	.9375	.9385	.9425	.8834	.8839	.8869
1	12	1.0000	1.0010	1.0050	.9459	.9464	.9494
$1 \frac{1}{16}$	12	1.0625	1.0635	1.0675	1.0084	1.0089	1.0119
$1 \frac{1}{8}$	12	1.1250	1.1265	1.1310	1.0709	1.0714	1.0749
$1 \frac{3}{8}$	12	1.1875	1.1890	1.1935	1.1334	1.1339	1.1374
$1 \frac{1}{2}$	12	1.2500	1.2515	1.2560	1.1959	1.1964	1.1999
$1 \frac{5}{8}$	12	1.3125	1.3140	1.3185	1.2584	1.2589	1.2624
$1 \frac{3}{4}$	12	1.3750	1.3765	1.3810	1.3209	1.3214	1.3249
$1 \frac{7}{8}$	12	1.4375	1.4390	1.4435	1.3834	1.3839	1.3874
$1 \frac{1}{2}$	12	1.5000	1.5015	1.5060	1.4459	1.4464	1.4499
$1 \frac{5}{8}$	12	1.6250	1.6265	1.6320	1.5709	1.5719	1.5759
$1 \frac{3}{4}$	12	1.7500	1.7515	1.7570	1.6959	1.6969	1.7009
$1 \frac{7}{8}$	12	1.8750	1.8765	1.8820	1.8209	1.8219	1.8259
2	12	2.0000	2.0015	2.0070	1.9459	1.9469	1.9509

LEAD TOLERANCE

A maximum lead error of plus or minus .003" in one inch of thread is permitted.



TABLE 334
Straight Pipe Taps
 Cut Thread—American National Form

THREAD LIMITS							
Nominal Size Inches	Threads per Inch NPS	Major Diameter			Pitch Diameter		
		Basic	Minimum	Maximum	Basic	Minimum	Maximum
$\frac{1}{8}$	27	.4044	.4011	.4041	.3748	.3733	.3763
$\frac{1}{4}$	18	.5343	.5301	.5331	.4899	.4884	.4914
$\frac{3}{8}$	18	.6714	.6670	.6705	.6270	.6253	.6288
$\frac{1}{2}$	14	.8356	.8303	.8338	.7784	.7767	.7802
$\frac{3}{4}$	14	1.0460	1.0405	1.0445	.9889	.9869	.9909
1	11½	1.3082	1.3018	1.3058	1.2386	1.2366	1.2406
1¼	11½	1.6530	1.6463	1.6508	1.5834	1.5811	1.5856
1½	11½	1.8919	1.8853	1.8898	1.8223	1.8201	1.8246
2	11½	2.3658	2.3590	2.3640	2.2963	2.2938	2.2988
2½	8	2.8622	2.8532	2.8587	2.7622	2.7594	2.7649
3	8	3.4885	3.4796	3.4851	3.3885	3.3858	3.3913
3½	8	3.9888	3.9799	3.9854	3.8888	3.8861	3.8916
4	8	4.4871	4.4782	4.4837	4.3871	4.3844	4.3899

Cut Thread — For Grease Cup Fittings

THREAD LIMITS							
Nominal Size Inches	Threads per Inch Grease	Major Diameter			Pitch Diameter		
		Basic	Minimum	Maximum	Basic	Minimum	Maximum
$\frac{1}{8}$	27	.4044	.3924	.3944	.3748	.3680	.3700
$\frac{1}{4}$	18	.5343	.5197	.5217	.4899	.4810	.4830
$\frac{3}{8}$	18	.6714	.6567	.6587	.6270	.6180	.6200
$\frac{1}{2}$	14	.8356	.8192	.8217	.7784	.7670	.7695
$\frac{3}{4}$	14	1.0460	1.0297	1.0322	.9889	.9775	.9800
1	11½	1.3082	1.2884	1.2909	1.2386	1.2245	1.2275

(Concluded on following page)

★ **"GREENFIELD" TOOLS** ★

TABLE 334
(Concluded)

Straight Pipe Taps Cut Thread—American National Form

LEAD TOLERANCE

A MAXIMUM lead error of plus or minus .003" in one inch of thread is permitted.

ANGLE TOLERANCE

Threads per Inch	Error in Half Angle	Error in Full Angle
8	40' Plus or Minus	80'
11½ to 27	45' Plus or Minus	68'

MARKING

In addition to regular marking, Grease Cup Fitting Taps should be marked "Grease."

FORMULAE FOR AMERICAN NATIONAL FORM (Approximate)

Minimum Major Diameter = Minimum pitch diameter plus (.75 x pitch)

Maximum Major Diameter = Minimum major diameter plus tolerance

Minimum Pitch Diameter = Basic minus ½ tolerance

Maximum Pitch Diameter = Minimum plus tolerance

Minor Diameter: The flat at the minor diameter shall not exceed:

.004" on 27 threads per inch

.005" on 18 threads per inch

.006" on 14 threads per inch

.007" on 11½ threads per inch

.008" on 8 threads per inch

FORMULAE FOR GREASE CUP FITTING TAPS (Approximate)

Maximum Major Diameter = { Maximum pitch diameter plus single thread
depth minus .005"

Minimum Major Diameter = Maximum minus Tolerance

Maximum Pitch Diameter = { Pitch Diameter at gaging notch of American "Briggs" Standard Taper Plug Gage
minus two threads

Minimum Pitch Diameter = Maximum minus Tolerance

Minor Diameter: The flat at the minor diameter shall not exceed.

.004" on 27 threads per inch

.005" on 18 threads per inch

.006" on 14 threads per inch

.007" on 11½ threads per inch

.008" on 8 threads per inch



TABLE 335

Straight Pipe Taps

Ground Thread—American National Form

THREAD LIMITS

Nominal Size Inches	Threads per Inch NPS.	Major Diameter			Pipe* Gage	Pitch Diameter		
		Basic	Mini- mum	Maxi- mum		Basic	Mini- mum	Maxi- mum
$\frac{1}{8}$	27	.4044	.4031	.4041	.3994	.3748	.3753	.3763
$\frac{1}{4}$	18	.5343	.5321	.5331	.5269	.4899	.4904	.4914
$\frac{3}{8}$	18	.6714	.6692	.6702	.6640	.6270	.6275	.6285
$\frac{1}{2}$	14	.8356	.8325	.8335	.8260	.7784	.7789	.7799
$\frac{3}{4}$	14	1.0460	1.0430	1.0440	1.0364	.9889	.9894	.9904
1	11 $\frac{1}{2}$	1.3082	1.3048	1.3063	1.2966	1.2386	1.2396	1.2407
1 $\frac{1}{4}$	11 $\frac{1}{2}$	1.6530	1.6496	1.6511	1.6413	1.5834	1.5844	1.5855
1 $\frac{1}{2}$	11 $\frac{1}{2}$	1.8919	1.8885	1.8900	1.8803	1.8223	1.8233	1.8244
2	11 $\frac{1}{2}$	2.3658	2.3625	2.3640	2.3542	2.2963	2.2973	2.2984
2 $\frac{1}{2}$	8	2.8622	2.8570	2.8585	2.8454	2.7622	2.7632	2.7646
3	8	3.4885	3.4833	3.4848	3.4718	3.3885	3.3895	3.3909
3 $\frac{1}{2}$	8	3.9888	3.9836	3.9851	3.9721	3.8888	3.8898	3.8912
4	8	4.4871	4.4819	4.4834	4.4704	4.3871	4.3881	4.3895

*See Column 5 Table 57, NSTC 1933 report.

Ground Thread—For Grease Cup Fittings

THREAD LIMITS

Nominal Size Inches	Threads per Inch Grease	Major Diameter			Pitch Diameter		
		Basic	Minimum	Maximum	Basic	Minimum	Maximum
$\frac{1}{8}$	27	.4044	.3929	.3944	.3748	.3690	.3700
$\frac{1}{4}$	18	.5343	.5202	.5217	.4899	.4820	.4830
$\frac{3}{8}$	18	.6714	.6572	.6587	.6270	.6190	.6200
$\frac{1}{2}$	14	.8356	.8202	.8217	.7784	.7680	.7695
$\frac{3}{4}$	14	1.0460	1.0307	1.0322	.9889	.9785	.9800
1	11 $\frac{1}{2}$	1.3082	1.2889	1.2909	1.2386	1.2260	1.2275

(Concluded on following page)



TABLE 335
(Concluded)

Straight Pipe Taps

Ground Thread—American National Form

LEAD TOLERANCE

A MAXIMUM lead error of plus or minus .0005" in one inch of thread is permitted.

ANGLE TOLERANCE

Threads per Inch	Error in Half Angle
8 11½ to 27 inclusive	25' Plus or Minus 30' Plus or Minus

MARKING

In addition to regular marking, Grease Cup Fitting Taps should be marked "Grease."

FORMULAE FOR AMERICAN NATIONAL FORM—(Approximate)

- Minimum Major Diameter = Minimum Pitch Diameter plus (.75 x pitch)
 Maximum Major Diameter = $\begin{cases} 8-11\frac{1}{2} \text{ threads per inch—Minimum plus .0015"} \\ 14-27 \text{ threads per inch—Minimum plus .001"} \end{cases}$
 Minimum Pitch Diameter = $\begin{cases} \frac{1}{8}" \text{ to } \frac{3}{4}" \text{ inclusive—Basic plus .0005"} \\ 1" \text{ to } 4" \text{ inclusive—Basic plus .0010"} \end{cases}$
 Maximum Pitch Diameter = Minimum pitch diameter plus "D" Table 331

Minor Diameter: The flat at the minor diameter shall not exceed:

- .004" on 27 threads per inch
- .005" on 18 threads per inch
- .006" on 14 threads per inch
- .007" on 11½ threads per inch
- .008" on 8 threads per inch

FORMULAE FOR GREASE CUP FITTING TAPS—(Approximate)

- Maximum Major Diameter = $\begin{cases} \text{Maximum pitch diameter plus single thread} \\ \text{depth minus .005"} \end{cases}$
 Minimum Major Diameter = Maximum minus Tolerance
 Maximum Pitch Diameter = $\begin{cases} \text{Pitch diameter at gaging notch of American} \\ \text{"Briggs" Standard Taper Plug Gage minus} \\ \text{two threads.} \end{cases}$
 Minimum Pitch Diameter = Maximum minus Tolerance

Minor Diameter: The flat at the minor diameter shall not exceed:

- .004" on 27 threads per inch
- .005" on 18 threads per inch
- .006" on 14 threads per inch
- .007" on 11½ threads per inch
- .008" on 8 threads per inch

NOTE

All American National Form ground thread straight pipe taps made to limits shown in first Table on preceding page should produce holes which will accept a basic straight pipe gage.



TABLE 336
Bent Shank Tapper Taps
 Class 2
 Cut Thread—American National Fine
THREAD LIMITS

Size	Threads per Inch National Fine	Major Diameter			Pitch Diameter		
		Basic	Minimum	Maximum	Basic	Minimum	Maximum
$\frac{1}{4}$	28	.2500	.2519	.2544	.2268	.2263	.2283
$\frac{5}{16}$	24	.3125	.3148	.3173	.2854	.2849	.2869
$\frac{3}{8}$	24	.3750	.3768	.3793	.3479	.3469	.3489
$\frac{1}{2}$	20	.4375	.4392	.4422	.4050	.4035	.4060
$\frac{5}{8}$	20	.5000	.5017	.5047	.4675	.4660	.4685
$\frac{3}{4}$	18	.5625	.5645	.5675	.5264	.5249	.5274
$\frac{7}{8}$	18	.6250	.6270	.6300	.5889	.5874	.5899
$1\frac{1}{4}$	16	.7500	.7519	.7559	.7094	.7074	.7104

LEAD TOLERANCE

A maximum lead error of plus or minus .003" in one inch of thread is permitted.

NOTE

Taps made to the above thread limits will be marked "Class 2" in addition to the regular marking.

TABLE 337
Bent Shank Tapper Taps
 Class 3
 American National Form
 High Speed Steel—Commercial Ground Thread
THREAD LIMITS

Size	Threads per Inch		Major Diameter			Pitch Diameter		
	NC	NF	Basic	Minimum	Maximum	Basic	Minimum	Maximum
$\frac{1}{4}$	20	..	.2500	.2531	.2541	.2175	.2171	.2181
$\frac{1}{4}$	..	28	.2500	.2512	.2522	.2268	.2260	.2270
$\frac{5}{16}$	18	..	.3125	.3165	.3175	.2764	.2764	.2774
$\frac{5}{16}$	..	24	.3125	.3143	.3153	.2854	.2847	.2857
$\frac{3}{8}$	16	..	.3750	.3797	.3807	.3344	.3346	.3356
$\frac{3}{8}$	..	24	.3750	.3768	.3778	.3479	.3472	.3482
$\frac{1}{2}$	14	..	.4375	.4436	.4446	.3911	.3917	.3927
$\frac{1}{2}$	..	20	.4375	.4405	.4415	.4050	.4045	.4055
$\frac{1}{2}$	13	..	.5000	.5067	.5077	.4500	.4507	.4517
$\frac{1}{2}$	..	20	.5000	.5030	.5040	.4675	.4670	.4680
$\frac{5}{8}$	12	..	.5625	.5695	.5705	.5084	.5094	.5104
$\frac{5}{8}$	..	18	.5625	.5663	.5673	.5264	.5262	.5272
$\frac{5}{8}$	11	..	.6250	.6325	.6335	.5660	.5670	.5681
$\frac{5}{8}$	..	18	.6250	.6288	.6298	.5889	.5887	.5897
$\frac{3}{4}$	10	..	.7500	.7580	.7595	.6850	.6860	.6871
$\frac{3}{4}$	..	16	.7500	.7544	.7554	.7094	.7093	.7103

NOTE: Taps made to the above thread limits will be marked "Class 3" in addition to the regular marking.



TABLE 338
Taper Pipe Taps
Cut and Ground Thread—American National Form
THREAD LIMITS AND TOLERANCES

Nom- inal Size In.	T'ds. per Inch NPT	*Gage Measurement Inches			Lead Toler- ance per Inch of Thread Plus or Minus Inches		Angle Tolerance			Taper per Foot Plus or Minus Inches	
		Pro- jec- tion	Tolerance Plus or Minus				Half Angle Plus or Minus		Full Angle Cut Thread		
			Cut Thread	Gr'd Thread			Cut Thread	Gr'd Thread		Cut Thread	Gr'd Thread
1/8	27	.312	1/16	1/16	.003	.0005	45'	30'	68'	1/16	1/32
1/4	18	.459	1/16	1/16	.003	.0005	45'	30'	68'	1/16	1/32
3/8	18	.454	1/16	1/16	.003	.0005	45'	30'	68'	1/16	1/32
1/2	14	.579	1/16	1/16	.003	.0005	45'	30'	68'	1/16	1/32
3/4	14	.565	1/16	1/16	.003	.0005	45'	30'	68'	1/16	1/32
1	11 1/2	.678	3/32	3/32	.003	.0005	45'	30'	68'	1/16	1/32
1 1/4	11 1/2	.686	3/32	3/32	.003	.0005	45'	30'	68'	1/16	1/32
1 1/2	11 1/2	.699	3/32	3/32	.003	.0005	45'	30'	68'	1/16	1/32
2	11 1/2	.667	3/32	3/32	.003	.0005	45'	30'	68'	1/16	1/32
2 1/2	8	.925	3/32	3/32	.003	.0005	40'	25'	60'	1/16	1/32
3	8	.925	3/32	3/32	.003	.0005	40'	25'	60'	1/16	1/32
3 1/2	8	.938	1/8	1/8	.003	.0005	40'	25'	60'	1/16	1/32
4	8	.950	1/8	1/8	.003	.0005	40'	25'	60'	1/16	1/32

* Distance small end of tap projects through American National Standard Ring Gage.

FORMULAE

Major diameter: The flat at the major diameter shall not exceed .067" x pitch of thread.

Minor diameter: The flat at the minor diameter shall not exceed:

.004" on 27 threads per inch
.005" on 18 threads per inch
.006" on 14 threads per inch
.007" on 11 1/2 threads per inch
.008" on 8 threads per inch

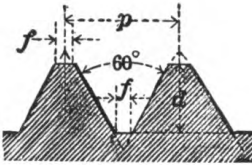
NOTE

For essential dimensions of American National Form Pipe Threads, see Table 357.

TABLE 351

Basic Thread Dimensions and Tap Drill Sizes

Fractional Sizes—American National Form



$$\text{Formula} \left\{ \begin{array}{l} p = \text{pitch} = \frac{1}{\text{No. thds. per in.}} \\ d = \text{depth} = p \times .64952 \\ f = \text{flat} = \frac{p}{8} \end{array} \right.$$

Nominal Size	Major Diameter Inches	Pitch Diameter Inches	Root Diameter Inches	Commercial Tap Drill to Produce Approx. 75% Full Thread	Decimal Equivalent of Tap Drill
1/16-64	.0625	.0524	.0422	3/64	.0469
72	.0625	.0535	.0445	3/64	.0469
5/64-60	.0781	.0673	.0563	1/16	.0625
72	.0781	.0691	.0601	52	.0635
3/32-48	.0938	.0803	.0667	49	.0730
50	.0938	.0808	.0678	49	.0730
7/64-48	.1094	.0959	.0823	43	.0890
1/8-32	.1250	.1047	.0844	3/32	.0937
40	.1250	.1088	.0925	38	.1015
9/64-40	.1406	.1244	.1081	32	.1160
5/32-32	.1563	.1360	.1157	1/8	.1250
36	.1563	.1382	.1202	30	.1285
11/64-32	.1719	.1516	.1313	9/64	.1406
3/16-24	.1875	.1604	.1334	26	.1470
32	.1875	.1672	.1469	22	.1570
13/64-24	.2031	.1760	.1490	20	.1610
7/32-24	.2188	.1917	.1646	16	.1770
32	.2188	.1985	.1782	12	.1890
15/64-24	.2344	.2073	.1806	10	.1935
1/4-20	.2500	.2175	.1850	7	.2010
24	.2500	.2229	.1959	4	.2090
27	.2500	.2260	.2019	3	.2130
28	.2500	.2268	.2036	3	.2130
32	.2500	.2297	.2094	7/32	.2188

(Continued on following page)

★ "GREENFIELD" TOOLS ★

TABLE 351

(Continued)

Basic Thread Dimensions and Tap Drill Sizes

Fractional Sizes—American National Form

Nominal Size	Major Diameter Inches	Pitch Diameter Inches	Root Diameter Inches	Commercial Tap Drill to Produce Approx. 75 % Full Thread	Decimal Equivalent of Tap Drill
$\frac{5}{16}$ -18	.3125	.2764	.2403	F	.2570
20	.3125	.2800	.2476	$\frac{17}{64}$	.2656
24	.3125	.2854	.2584	I	.2720
27	.3125	.2884	.2644	J	.2770
32	.3125	.2922	.2719	$\frac{9}{32}$	.2812
$\frac{3}{8}$ -16	.3750	.3344	.2938	$\frac{5}{16}$	.3125
20	.3750	.3425	.3100	$\frac{21}{64}$	.3281
24	.3750	.3479	.3209	Q	.3320
27	.3750	.3509	.3269	R	.3390
$\frac{7}{16}$ -14	.4375	.3911	.3447	U	.3680
20	.4375	.4050	.3726	$\frac{25}{64}$	.3906
24	.4375	.4104	.3834	X	.3970
27	.4375	.4134	.3894	Y	.4040
$\frac{1}{2}$ -12	.5000	.4459	.3918	$\frac{27}{64}$	.4219
13	.5000	.4500	.4001	$\frac{27}{64}$	.4219
20	.5000	.4675	.4351	$\frac{29}{64}$	.4531
24	.5000	.4729	.4459	$\frac{29}{64}$	.4531
27	.5000	.4759	.4519	$\frac{15}{32}$	.4687
$\frac{9}{16}$ -12	.5625	.5084	.4542	$\frac{31}{64}$	.4844
18	.5625	.5264	.4903	$\frac{33}{64}$	.5156
27	.5625	.5384	.5144	$\frac{17}{32}$	.5312
$\frac{5}{8}$ -11	.6250	.5660	.5069	$\frac{17}{32}$	.5312
12	.6250	.5709	.5168	$\frac{35}{64}$	.5469
18	.6250	.5889	.5528	$\frac{37}{64}$	.5781
27	.6250	.6009	.5769	$\frac{19}{32}$	.5937
$\frac{11}{16}$ -11	.6875	.6285	.5694	$\frac{19}{32}$	.5937
16	.6875	.6469	.6063	$\frac{5}{8}$	.6250
$\frac{3}{4}$ -10	.7500	.6850	.6201	$\frac{21}{32}$	.6562
12	.7500	.6959	.6418	$\frac{43}{64}$	.6719
16	.7500	.7094	.6688	$\frac{11}{16}$.6875
27	.7500	.7259	.7019	$\frac{23}{32}$.7187
$\frac{13}{16}$ -10	.8125	.7476	.6826	$\frac{23}{32}$.7187

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★ "GREENFIELD" TOOLS ★

TABLE 351
(Concluded)

Basic Thread Dimensions and Tap Drill Sizes

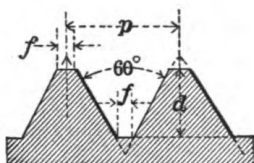
Fractional Sizes—American National Form

Nominal Size	Major Diameter Inches	Pitch Diameter Inches	Root Diameter Inches	Commercial Tap Drill to Produce Approx. 75% Full Thread	Decimal Equivalent of Tap Drill
$\frac{7}{8}$ - 9	.8750	.8028	.7307	$\frac{49}{64}$	.7656
12	.8750	.8209	.7668	$\frac{51}{64}$	.7969
14	.8750	.8286	.7822	$\frac{13}{16}$	.8125
18	.8750	.8389	.8028	$\frac{53}{64}$	.8281
27	.8750	.8509	.8269	$\frac{27}{32}$	.8437
$\frac{15}{16}$ - 9	.9375	.8654	.7932	$\frac{53}{64}$	.8281
1 - 8	1.0000	.9188	.8376	$\frac{7}{8}$	.8750
12	1.0000	.9459	.8918	$\frac{59}{64}$	.9219
14	1.0000	.9536	.9072	$\frac{15}{16}$	.9375
27	1.0000	.9759	.9519	$\frac{31}{32}$	.9687
$1\frac{1}{8}$ - 7	1.1250	1.0322	.9394	$\frac{63}{64}$	.9844
12	1.1250	1.0709	1.0168	$1\frac{3}{64}$	1.0469
$1\frac{1}{4}$ - 7	1.2500	1.1572	1.0644	$1\frac{7}{64}$	1.1094
12	1.2500	1.1959	1.1418	$\frac{111}{64}$	1.1719
$1\frac{3}{8}$ - 6	1.3750	1.2667	1.1585	$\frac{113}{64}$	1.2187
12	1.3750	1.3209	1.2668	$\frac{119}{64}$	1.2969
$1\frac{1}{2}$ - 6	1.5000	1.3917	1.2835	$\frac{111}{32}$	1.3437
12	1.5000	1.4459	1.3918	$\frac{127}{64}$	1.4219
$1\frac{5}{8}$ - $5\frac{1}{2}$	1.6250	1.5069	1.3888	$\frac{129}{64}$	1.4531
$1\frac{3}{4}$ - 5	1.7500	1.6201	1.4902	$1\frac{9}{16}$	1.5625
$1\frac{7}{8}$ - 5	1.8750	1.7451	1.6152	$\frac{111}{16}$	1.6875
2 - $4\frac{1}{2}$	2.0000	1.8557	1.7113	$\frac{125}{32}$	1.7812
$2\frac{1}{8}$ - $4\frac{1}{2}$	2.1250	1.9807	1.8363	$\frac{129}{32}$	1.9062
$2\frac{1}{4}$ - $4\frac{1}{2}$	2.2500	2.1057	1.9613	$2\frac{1}{32}$	2.0312
$2\frac{3}{8}$ - 4	2.3750	2.2126	2.0502	$2\frac{1}{8}$	2.1250
$2\frac{1}{2}$ - 4	2.5000	2.3376	2.1752	$2\frac{1}{4}$	2.2500
$2\frac{3}{4}$ - 4	2.7500	2.5876	2.4252	$2\frac{1}{2}$	2.5000
3 - 4	3.0000	2.8376	2.6752	$2\frac{3}{4}$	2.7500
$3\frac{1}{4}$ - 4	3.2500	3.0876	2.9252	3	3.0000
$3\frac{1}{2}$ - 4	3.5000	3.3376	3.1752	$3\frac{1}{4}$	3.2500
$3\frac{3}{4}$ - 4	3.7500	3.5876	3.4252	$3\frac{1}{2}$	3.5000
4 - 4	4.0000	3.8376	3.6752	$3\frac{3}{4}$	3.7500

TABLE 352

Basic Thread Dimensions and Tap Drill Sizes

Machine Screw Sizes—American National Form



$$\text{Formula } \left\{ \begin{array}{l} p = \text{pitch} = \frac{1}{\text{No. thds. per in.}} \\ d = \text{depth} = p \times .64952 \\ f = \text{flat} = \frac{p}{8} \end{array} \right.$$

Screw Gage Number	Major Diameter Inches	Pitch Diameter Inches	Root Diameter Inches	Commercial Tap Drill to Produce Approx. 75% Full Thread	Decimal Equivalent of Tap Drill
0-80	.0600	.0519	.0438	$\frac{3}{64}$	.0469
1-56	.0730	.0614	.0498	54	.0550
64	.0730	.0629	.0527	53	.0595
72	.0730	.0640	.0550	53	.0595
2-56	.0860	.0744	.0628	50	.0700
64	.0860	.0759	.0657	49	.0700
3-48	.0990	.0855	.0719	46	.0785
56	.0990	.0874	.0758	45	.0820
4-32	.1120	.0917	.0714	45	.0820
36	.1120	.0940	.0759	44	.0860
40	.1120	.0958	.0795	43	.0890
48	.1120	.0985	.0849	42	.0935
5-36	.1250	.1070	.0889	40	.0980
40	.1250	.1088	.0925	38	.1015
44	.1250	.1102	.0955	37	.1040
6-32	.1380	.1177	.0974	35	.1065
36	.1380	.1200	.1019	34	.1110
40	.1380	.1218	.1055	33	.1130
7-30	.1510	.1294	.1077	31	.1200
32	.1510	.1307	.1104	31	.1200
36	.1510	.1330	.1149	$\frac{1}{8}$.1250

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★ "GREENFIELD" TOOLS ★

TABLE 352

(Concluded)

Basic Thread Dimensions and Tap Drill Sizes

Machine Screw Sizes—American National Form

Screw Gage Number	Major Diameter Inches	Pitch Diameter Inches	Root Diameter Inches	Commercial Tap Drill to Produce Approx. 75% Full Thread	Decimal Equivalent of Tap Drill
8-30	.1640	.1423	.1207	30	.1285
32	.1640	.1437	.1234	29	.1360
36	.1640	.1460	.1279	29	.1360
40	.1640	.1478	.1315	28	.1405
9-24	.1770	.1499	.1229	29	.1360
30	.1770	.1553	.1337	27	.1440
32	.1770	.1567	.1364	26	.1470
10-24	.1900	.1629	.1359	25	.1495
28	.1900	.1668	.1436	23	.1540
30	.1900	.1684	.1467	22	.1570
32	.1900	.1697	.1494	21	.1590
12-24	.2160	.1889	.1619	16	.1770
28	.2160	.1928	.1696	14	.1820
32	.2160	.1957	.1754	13	.1850
14-20	.2420	.2095	.1770	10	.1935
24	.2420	.2149	.1879	7	.2010
16-18	.2680	.2319	.1958	3	.2130
20	.2680	.2355	.2030	$\frac{7}{32}$	.2187
22	.2680	.2385	.2090	2	.2210
18-18	.2940	.2579	.2218	B	.2380
20	.2940	.2615	.2290	D	.2460
20-16	.3200	.2794	.2388	G	.2610
18	.3200	.2839	.2478	$\frac{17}{64}$	.2656
20	.3200	.2875	.2550	I	.2720
22-16	.3460	.3054	.2648	$\frac{9}{32}$	.2812
18	.3460	.3099	.2738	L	.2900
24-16	.3720	.3314	.2908	$\frac{5}{16}$	.3125
18	.3720	.3359	.2998	O	.3160
26-14	.3980	.3516	.3052	$\frac{21}{64}$	.3281
16	.3980	.3574	.3168	R	.3390
28-14	.4240	.3776	.3312	T	.3580
16	.4240	.3834	.3428	$\frac{23}{64}$.3594
30-14	.4500	.4036	.3572	V	.3770
16	.4500	.4094	.3688	$\frac{25}{64}$.3906

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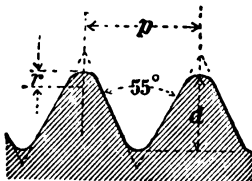
"GREENFIELD" TOOLS

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TABLE 353

Basic Thread Dimensions
and Tap Drill Sizes

British Standard—Whitworth Form



Formula

$$\left\{ \begin{array}{l} p = \text{pitch} = \frac{1}{\text{No. thds. per in.}} \\ d = \text{depth} = p \times .64033 \\ r = \text{radius} = p \times .1373 \end{array} \right.$$

Nominal Size	Major Diameter Inches	Pitch Diameter Inches	Root Diameter Inches	Commercial Tap Drill to Produce Approximately Full Thread	Decimal Equivalent of Drill
1/16-60	.0625	.0518	.0412	57	.0430
3/32-48	.0938	.0804	.0671	50	.0700
1/8-40	.1250	.1090	.0930	40	.0980
5/32-32	.1563	.1362	.1162	31	.1200
3/16-24	.1875	.1608	.1341	28	.1405
7/32-24	.2188	.1921	.1654	17	.1730
1/4-20	.2500	.2180	.1860	9	.1960
26	.2500	.2254	.2001	4	.2090
9/32-26	.2813	.2566	.2321	C	.2420
5/16-18	.3125	.2769	.2414	1/4	.2500
22	.3125	.2834	.2543	G	.2610
3/8-16	.3750	.3350	.2950	5/16	.3125
20	.3750	.3430	.3110	P	.3230
7/16-14	.4375	.3918	.3460	T	.3580
18	.4375	.4019	.3665	3/8	.3750
1/2-12	.5000	.4466	.3933	Z	.4130
16	.5000	.4600	.4200	7/16	.4375
9/16-12	.5625	.5091	.4558	15/32	.4687
16	.5625	.5225	.4825	1/2	.5000
5/8-11	.6250	.5668	.5086	17/32	.5312
14	.6250	.5793	.5336	35/64	.5469
11/16-11	.6875	.6293	.5711	19/32	.5937
14	.6875	.6418	.5961	39/64	.6094

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★ "GREENFIELD" TOOLS ★

TABLE 353

(Concluded)

Basic Thread Dimensions and Tap Drill Sizes

British Standard—Whitworth Form

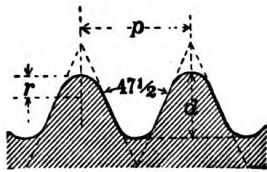
Nominal Size	Major Diameter Inches	Pitch Diameter Inches	Root Diameter Inches	Commercial Tap Drill to Produce Approximately Full Thread	Decimal Equivalent of Drill
$\frac{3}{4}$ -10	.7500	.6860	.6219	$\frac{41}{64}$	.6406
12	.7500	.6966	.6434	$\frac{21}{32}$	.6562
$\frac{13}{16}$ -10	.8125	.7485	.6844	$\frac{45}{64}$	.7031
12	.8125	.7591	.7059	$\frac{23}{32}$	.7187
$\frac{7}{8}$ -9	.8750	.8039	.7327	$\frac{3}{4}$	.7500
11	.8750	.8168	.7586	$\frac{25}{32}$	.7812
$\frac{15}{16}$ -9	.9375	.8664	.7952	$\frac{13}{16}$	.8125
1-8	1.0000	.9200	.8399	$\frac{55}{64}$	.8593
10	1.0000	.9360	.8720	$\frac{57}{64}$	.8906
$1\frac{1}{8}$ -7	1.1250	1.0335	.9420	$\frac{31}{32}$	.9687
9	1.1250	1.0539	.9828	1	1.0000
$1\frac{1}{4}$ -7	1.2500	1.1585	1.0670	$1\frac{3}{32}$	1.0937
9	1.2500	1.1789	1.1078	$1\frac{1}{8}$	1.1250
$1\frac{3}{8}$ -6	1.3750	1.2683	1.1616	$1\frac{5}{16}$	1.1875
8	1.3750	1.2950	1.2150	$\frac{115}{64}$	1.2343
$1\frac{1}{2}$ -6	1.5000	1.3933	1.2866	$1\frac{5}{16}$	1.3125
8	1.5000	1.4200	1.3400	$1\frac{3}{8}$	1.3750
$1\frac{5}{8}$ -5	1.6250	1.4969	1.3689	$\frac{119}{32}$	1.4062
$1\frac{3}{4}$ -5	1.7500	1.6219	1.4939	$\frac{117}{32}$	1.5312
$1\frac{7}{8}$ -4 $\frac{1}{2}$	1.8750	1.7327	1.5904	$1\frac{5}{8}$	1.6250
2-4 $\frac{1}{2}$	2.0000	1.8577	1.7154	$1\frac{3}{4}$	1.7500
$2\frac{1}{8}$ -4 $\frac{1}{2}$	2.1250	1.9827	1.8404	$1\frac{7}{8}$	1.8750
$2\frac{1}{4}$ -4	2.2500	2.0899	1.9298	$\frac{131}{32}$	1.9687
$2\frac{3}{8}$ -4	2.3750	2.2149	2.0548	$2\frac{3}{32}$	2.0937
$2\frac{1}{2}$ -4	2.5000	2.3399	2.1798	$2\frac{7}{32}$	2.2187
$2\frac{3}{4}$ -3 $\frac{1}{2}$	2.7500	2.5671	2.3841	$2\frac{7}{16}$	2.4375
3-3 $\frac{1}{2}$	3.0000	2.8171	2.6341	$2\frac{11}{16}$	2.6875
$3\frac{1}{4}$ -3 $\frac{1}{4}$	3.2500	3.0530	2.8560	$2\frac{7}{8}$	2.8750
$3\frac{1}{2}$ -3 $\frac{1}{4}$	3.5000	3.3030	3.1060	$3\frac{1}{8}$	3.1250
$3\frac{3}{4}$ -3	3.7500	3.5366	3.3231	$3\frac{3}{8}$	3.3750
4-3	4.0000	3.7866	3.5731	$3\frac{5}{8}$	3.6250

★ "GREENFIELD" TOOLS ★

TABLE 354

Basic Thread Dimensions and Tap Drill Sizes

British Association Standard



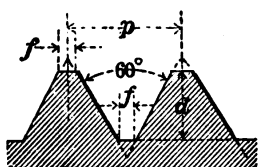
Formula

$$\begin{cases} p = \text{pitch} \\ d = \text{depth} = p \times .6 \\ r = \text{radius} = \frac{2 \times p}{11} \end{cases}$$

Number	Pitch m/m	Major Diameter m/m	Pitch Diameter m/m	Root Diameter m/m	Commercial Tap Drill to Produce Approximately Full Thread
0	1.00	6.0	5.400	4.80	10
1	.90	5.3	4.760	4.22	17
2	.81	4.7	4.215	3.73	24
3	.73	4.1	3.660	3.22	29
4	.66	3.6	3.205	2.81	32
5	.59	3.2	2.845	2.49	37
6	.53	2.8	2.480	2.16	43
7	.48	2.5	2.210	1.92	46
8	.43	2.2	1.940	1.68	50
9	.39	1.9	1.665	1.43	53
10	.35	1.7	1.490	1.28	55
11	.31	1.5	1.315	1.13	56
12	.28	1.3	1.130	.96	60
14	.23	1.0	.860	.72	70

★ "GREENFIELD" TOOLS ★

TABLE 355
**Basic Thread Dimensions
 and Tap Drill Sizes**
 French and International Standard



$$\text{Formula} \begin{cases} p = \text{pitch} \\ d = \text{depth} = p \times .64952 \\ f = \text{flat} = \frac{p}{8} \end{cases}$$

Nominal Diameter m/m	Pitch m/m			Pitch Diameter m/m	Root Diameter m/m	Commercial Tap Drill to Produce Approx. 75% Full Thread
	French Std.	International Std. (D.I.N.)	Optional			
1.5	.35	...	...	1.273	1.05	1.1
2	...	.40	...	1.740	1.48	1.6
2	.45	...	...	1.708	1.42	1.5
2	...	...	.50	1.675	1.35	1.5
2.3	...	.40	...	2.040	1.78	1.9
2.5	.45	...	...	2.208	1.92	2.0
2.6	...	.45	...	2.308	2.02	2.1
3	...	.50	...	2.675	2.35	2.5
3	.60	...	...	2.610	2.22	2.4
3	...	...	.75	2.513	2.03	2.25
3.5	.60	.60	...	3.110	2.72	2.9
4	...	.70	...	3.545	3.09	3.3
4	.75	...	...	3.513	3.03	3.25
4.5	.75	.75	...	4.013	3.53	3.75
5	...	...	.75	4.513	4.03	4.25
5	...	.80	...	4.480	3.96	4.2
5	.90	...	...	4.415	3.83	4.1
5	...	...	1.00	4.350	3.70	4.0
5.5	...	...	.75	5.013	4.53	4.75
5.5	.90	.90	...	4.915	4.33	4.6
6	1.00	1.00	...	5.350	4.70	5.0
6	...	...	1.25	5.188	4.38	4.8
7	1.00	1.00	...	6.350	5.70	6.0
7	1.25	6.188	5.38	5.8
8	1.00	7.350	6.70	7.0
8	...	1.25	...	7.188	6.38	6.8
9	1.00	8.350	7.70	8.0
9	...	1.25	...	8.188	7.38	7.8

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TABLE 355

(Concluded)

Basic Thread Dimensions and Tap Drill Sizes

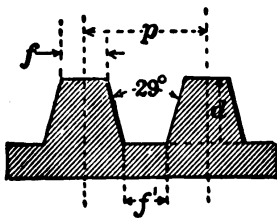
French and International Standard

Nominal Diameter m/m	Pitch m/m			Pitch Diameter m/m	Root Diameter m/m	Commercial Tap Drill to Produce Approx. 75% Full Thread
	French Std.	Inter- national Std. (D.I.N.)	Optional			
10	....	....	1.25	9.188	8.38	8.8
10	1.50	1.50	....	9.026	8.05	8.6
11	....	1.50	....	10.026	9.05	9.6
12	....	....	1.25	11.188	10.38	11.0
12	1.50	....	....	11.026	10.05	10.5
12	....	1.75	....	10.863	9.73	10.5
13	....	....	1.50	12.026	11.05	11.5
13	....	....	1.75	11.863	10.73	11.5
13	....	....	2.00	11.701	10.40	11.0
14	....	....	1.25*	13.188	12.38	13.0
14	....	....	1.75	12.863	11.73	12.5
14	2.00	2.00	....	12.701	11.40	12.0
15	....	....	1.75	13.863	12.73	13.5
15	....	....	2.00	13.701	12.40	13.0
16	2.00	2.00	....	14.701	13.40	14.0
17	....	....	2.00	15.701	14.40	15.0
18	....	....	1.50*	17.026	16.05	16.5
18	....	....	2.00	16.701	15.40	16.0
18	2.50	2.50	....	16.376	14.75	15.5
19	....	....	2.50	17.376	15.75	16.5
20	....	....	2.00	18.701	17.40	18.0
20	2.50	2.50	....	18.376	16.75	17.5
22	2.50	2.50	....	20.376	18.75	19.5
24	3.00	3.00	....	22.051	20.10	21.0
26	3.00	....	....	24.051	22.10	23.0
27	....	3.00	....	25.051	23.10	24.0
28	3.00	....	....	26.051	24.10	25.0
30	3.50	3.50	....	27.727	25.45	26.5
32	3.50	....	....	29.727	27.45	28.5
33	....	3.50	....	30.727	28.45	29.5
34	3.50	....	....	31.727	29.45	30.5
36	4.00	4.00	....	33.402	30.80	32.0
38	4.00	....	....	35.402	32.80	34.0
39	....	4.00	....	36.402	33.80	35.0
40	4.00	....	....	37.402	34.80	36.0
42	4.50	4.50	....	39.077	36.15	37.0
44	4.50	....	....	41.077	38.15	39.0
45	....	4.50	....	42.077	39.15	40.0
46	4.50	....	....	43.077	40.15	41.0
48	5.00	5.00	....	44.752	41.50	43.0
50	5.00	....	....	46.752	43.50	45.0

*Spark Plug Sizes.

★ "GREENFIELD" TOOLS ★

TABLE 356
Basic Thread Dimensions
American National Acme Screw Thread



SYMBOLS:

- d = Depth of thread with clearance
- D = { Tap drill
Minor diameter of nut
- f = Width of flat at top of thread
- f' = Width of flat at bottom of space
- n = Number of threads per inch
- p = Pitch of thread
- R = Minor diameter of screw
- S = Major diameter of screw
- T = Major diameter of tap

FORMULAE (Approximate)

$$p = \frac{1}{n}$$

$$D = S - p$$

$$f = \frac{.3707}{n}$$

$$R = S - 2d$$

For 10 or less threads per inch

$$d = \frac{p}{2} \text{ plus } .010$$

$$f' = \frac{.3707}{n} \text{ minus } .0052$$

$$T = S \text{ plus } .020$$

For more than 10 threads per inch

$$d = \frac{p}{2} \text{ plus } .005$$

$$f' = \frac{.3707}{n} \text{ minus } .0026$$

$$T = S \text{ plus } .010$$

TABLE OF THREAD PARTS

Pitch (p)	Threads per Inch (n)	Depth of Thread with Clearance (d)	Flat at Top of Thread (f)	Flat at Bottom of Space (f')	Space at Top of Thread	Thickness at Root of Thread
1	1	.5100	.3707	.3655	.6293	.6345
3/4	1 1/3	.3850	.2780	.2728	.4720	.4772
1/2	2	.2600	.1854	.1802	.3146	.3198
1/3	3	.1767	.1236	.1184	.2097	.2149
1/4	4	.1350	.0927	.0875	.1573	.1625
1/5	5	.1100	.0741	.0689	.1259	.1311
1/6	6	.0933	.0618	.0566	.1049	.1101
1/7	7	.0814	.0530	.0478	.0899	.0951
1/8	8	.0725	.0463	.0411	.0787	.0839
1/9	9	.0655	.0412	.0360	.0699	.0751
1/10	10	.0600	.0371	.0319	.0629	.0681
1/12	12	.0467	.0309	.0283	.0524	.0550
1/14	14	.0407	.0265	.0239	.0449	.0475
1/16	16	.0363	.0232	.0206	.0393	.0419

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★ "GREENFIELD" TOOLS ★

TABLE 356
(Concluded)

Basic Thread Dimensions

American National Acme Screw Thread

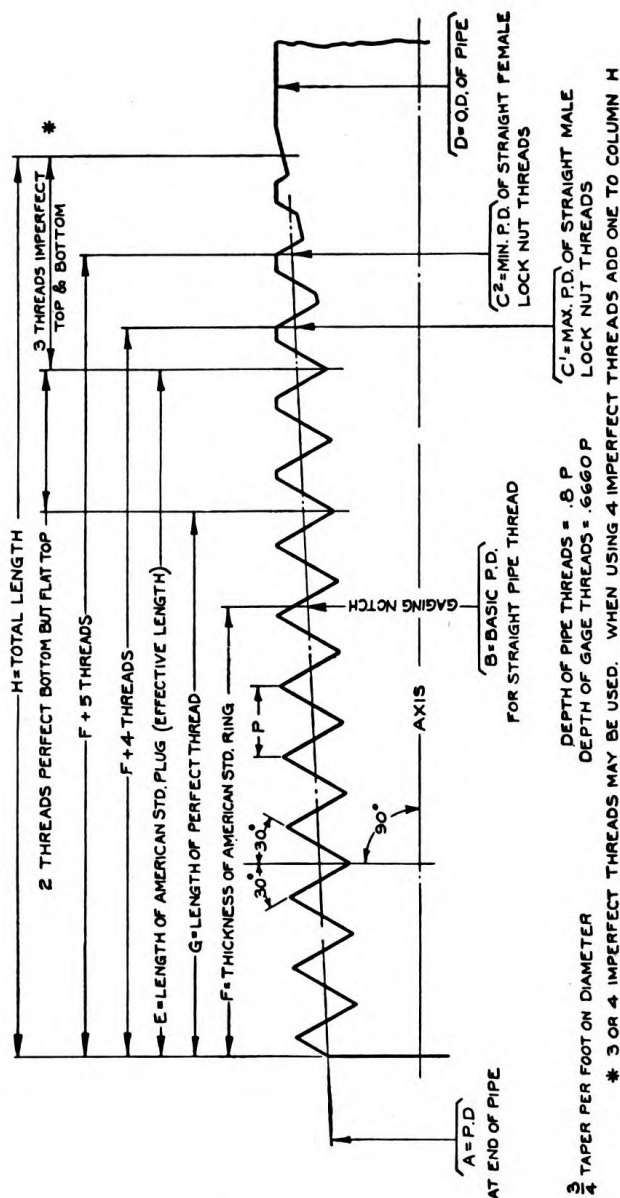
General Purpose Series

THESE Acme threads are designated by N. S. T. C. as standard. There are a number of reasons which make it both economical and advantageous to adopt Acme screws from this table. For example, all items $\frac{1}{2}$ " and larger have pitches which permit the use of evenly graduated dials on lead screws. Helix angles are 5° or less, making for ease of manufacture. Threads are strong in proportion to diameters.

If a greater lead is required on a given diameter than the thread recommended it is advisable to use a multiple thread of that lead rather than a single thread of that pitch.

Size Inches	Threads per Inch (N)	Basic Dimensions			Thread Data			
		Major Diameter (S)	Pitch Diameter (D)	Minor Diameter (D)	Thickness at Pitch Line (p/2)	Depth Thread with Clearance (d)	Basic Width of Flat (f)	Helix Angle at Pitch Diam.
$\frac{1}{4}$	16	.2500	.2188	.1875	.0313	.0363	.0232	$5^\circ 12'$
$\frac{5}{16}$	14	.3125	.2768	.2411	.0357	.0407	.0265	$4^\circ 42'$
$\frac{3}{8}$	12	.3750	.3333	.2917	.0417	.0467	.0309	$4^\circ 33'$
$\frac{7}{16}$	12	.4375	.3958	.3542	.0417	.0467	.0309	$3^\circ 50'$
$\frac{1}{2}$	10	.5000	.4500	.4000	.0500	.0600	.0371	$4^\circ 3'$
$\frac{5}{8}$	8	.6250	.5625	.5000	.0625	.0725	.0463	$4^\circ 3'$
$\frac{3}{4}$	8	.7500	.6875	.6250	.0625	.0725	.0463	$3^\circ 19'$
$\frac{7}{8}$	8	.8750	.8125	.7500	.0625	.0725	.0463	$2^\circ 48'$
1	5	1.0000	.9000	.8000	.1000	.1100	.0741	$4^\circ 3'$
$1\frac{1}{8}$	5	1.1250	1.0250	.9250	.1000	.1100	.0741	$3^\circ 33'$
$1\frac{1}{4}$	5	1.2500	1.1500	1.0500	.1000	.1100	.0741	$3^\circ 10'$
$1\frac{3}{8}$	5	1.3750	1.2750	1.1750	.1000	.1100	.0741	$2^\circ 52'$
$1\frac{1}{2}$	4	1.5000	1.3750	1.2500	.1250	.1350	.0927	$3^\circ 19'$
$1\frac{3}{4}$	4	1.7500	1.6250	1.5000	.1250	.1350	.0927	$2^\circ 48'$
2	4	2.0000	1.8750	1.7500	.1250	.1350	.0927	$2^\circ 26'$
$2\frac{1}{2}$	2	2.5000	2.2500	2.0000	.2500	.2600	.1854	$4^\circ 3'$
3	2	3.0000	2.7500	2.5000	.2500	.2600	.1854	$3^\circ 19'$
4	2	4.0000	3.7500	3.5000	.2500	.2600	.1854	$2^\circ 26'$
5	2	5.0000	4.7500	4.5000	.2500	.2600	.1854	$1^\circ 55'$

TABLE 357
American National Pipe Threads
With Locknut Threads and Basic Straight Pipe Sizes



$\frac{3}{4}$ TAPER PER FOOT ON DIAMETER
* 3 OR 4 IMPERFECT THREADS MAY BE USED. WHEN USING 4 IMPERFECT THREADS ADD ONE TO COLUMN H

(See Table on following page)

TABLE 357—American National Pipe Threads—(Concluded)

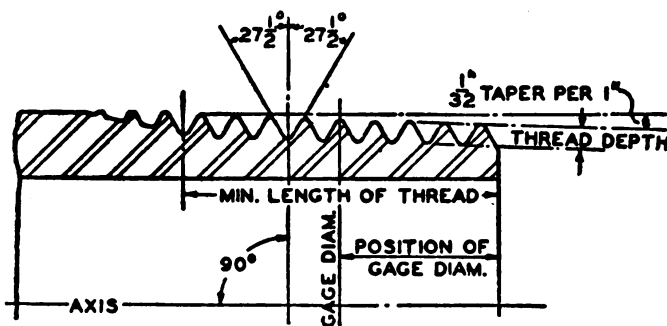
With Locknut Threads and Basic Straight Pipe Sizes

Pipe Size—Inches	Threads per Inch	Outside Diameter Pipe—Inches	Pitch—Inches	Depth of Thread .8 Pitch—Inches	Pitch Diameter at Gage Notch Basic Straight—Inches	Pitch Diameter at End of Pipe— Inches	Thickness of Ann. St. Ring Gage (also distance from small end to gaging notch)—Inches	Length of Ameri- can Standard Plug (effective length of thread on pipe)—In.	H	C ¹ Maximum Pitch Diameter, Straight Thread—Inches	C ² Minimum Pitch Diameter, Straight Thread—Inches	*Tap Drill Size
1/8	27	.405	.03704	.0296	.3748	.3635	.180	.2638	.3749	.3840	.3863	11/32
1/4	18	.540	.05556	.0444	.4899	.4774	.200	.4018	.5685	.5038	.5073	7/16
3/8	18	.675	.05556	.0444	.6270	.6120	.240	.4078	.5745	.6409	.6444	37/64
1/2	14	.840	.07143	.0571	.7784	.7584	.320	.5337	.7480	.7963	.8008	23/32
3/4	14	1.050	.07143	.0571	.9889	.9677	.339	.5457	.7600	1.0067	1.0112	59/64
1	11 1/2	1.315	.08696	.0696	1.2386	1.2136	.400	.6828	.9437	1.2604	1.2658	1 5/32
1 1/4	11 1/2	1.660	.08696	.0696	1.5834	1.5571	.420	.7068	.9677	1.6051	1.6106	1 1/2
1 1/2	11 1/2	1.900	.08696	.0696	1.8223	1.7961	.420	.7235	.9844	1.8441	1.8495	1 7/8
2	8	2.375	.12500	.1000	2.2963	2.2690	.436	.7565	1.0174	2.3180	2.3234	2 1/8
2 1/2	8	2.875	.12500	.1000	2.7622	2.7195	.682	1.1375	1.5125	2.7934	2.8012	2 5/8
3	8	3.500	.12500	.1000	3.3885	3.3406	.766	1.2000	1.5750	3.4198	3.4276	3 1/4
3 1/2	8	4.000	.12500	.1000	3.8888	3.8375	.821	1.2500	1.6250	3.9201	3.9279	3 3/4
4	8	4.500	.12500	.1000	4.3871	4.3344	.844	1.3000	1.6750	4.4184	4.4262	4 1/4
4 1/2	8	5.000	.12500	.1000	4.8859	4.8313	.875	1.3500	1.7250	4.9172	4.9250	...
5	8	5.563	.12500	.1000	5.4493	5.3907	.937	1.4063	1.7813	5.4806	5.4884	...
6	8	6.625	.12500	.1000	6.5060	6.4461	.958	1.5125	1.8875	6.5372	6.5450	...
8	8	8.625	.12500	.1000	8.5000	8.4336	1.063	1.7125	2.0875	8.5313	8.5391	...
10	8	10.750	.12500	.1000	10.6209	10.5453	1.210	1.9250	2.3000	10.6522	10.6600	...
12	8	12.750	.12500	.1000	12.6178	12.5328	1.360	2.1250	2.5000	12.6491	12.6569	...

*Tap drill sizes given permit of direct tapping without reaming the hole.

★ "GREENFIELD" TOOLS ★

TABLE 358
Basic Thread Dimensions and Tap Drill Sizes
 British Standard Pipe Thread, Whitworth Form



Formula $\left\{ \begin{array}{l} N = \text{number of threads per inch} \\ \text{Depth of thread} = \frac{.64}{N} \end{array} \right.$

Pipe Diameters		Threads per Inch	Depth of Thread	Theoretical Gage Diam.	Distance from Small End to Gage Diam.	Minimum Length of Thread	*Tap Drill Size
Pipe Size Nominal Inside	Approx. Outside						
1/8	13/32	28	.0229	.383	5/32	3/8	21/64
1/4	17/32	19	.0337	.518	3/16	7/16	29/64
3/8	1 1/16	19	.0337	.656	1/4	1 1/2	37/64
1/2	2 1/8	14	.0457	.825	1/4	5/8	23/32
5/8	2 1/2	14	.0457	.902	1/4	5/8	51/64
3/4	2 7/8	14	.0457	1.041	3/8	3/4	59/64
7/8	3 1/8	14	.0457	1.189	3/8	3/4	1 1/16
1	3 1/2	11	.0582	1.309	3/8	7/8	1 11/64
1 1/4	4 1/8	11	.0582	1.650	1/2	1	1 1/2
1 1/2	4 3/4	11	.0582	1.882	1/2	1	1 3/4
1 3/4	5 1/8	11	.0582	2.116	5/8	1 1/8	1 31/32
2	6 1/8	11	.0582	2.347	5/8	1 1/8	2 7/32
2 1/4	6 3/4	11	.0582	2.587	1 1/16	1 1/4	2 7/16
2 1/2	7 1/8	11	.0582	2.960	1 1/16	1 1/4	2 13/16
2 3/4	7 3/4	11	.0582	3.210	1 3/16	1 3/8	3 1/16
3	8 1/2	11	.0582	3.460	1 3/16	1 3/8	3 5/16
3 1/4	9 1/8	11	.0582	3.700	7/8	1 1/2	3 9/16
3 1/2	9 3/4	11	.0582	3.950	7/8	1 1/2	3 13/16
3 3/4	10 1/4	11	.0582	4.200	7/8	1 1/2	...
4	10 3/4	11	.0582	4.450	1	1 5/8	...
4 1/2	11 1/2	11	.0582	4.950	1	1 5/8	...
5	12 1/2	11	.0582	5.450	1 1/8	1 3/4	...
5 1/2	13 1/2	11	.0582	5.950	1 1/4	1 7/8	...
6	14 1/2	11	.0582	6.450	1 3/8	2	...

*Tap drill sizes given permit of direct tapping without reaming the hole.

★ "GREENFIELD" TOOLS ★

Table of Thread Elements

T. P. I. Threads per inch.

Pitch. Distance from a point on a thread to the corresponding point on the next thread.

S. Depth. Single Depth of National Form of thread and is amount to deduct from major diameter to obtain the pitch diameter.

D. Depth. Double Depth of National Form of thread is amount to deduct from major diameter to obtain minor diameter.

83⅓% D. Depth. 83⅓% Double Depth or amount to deduct from major diameter to obtain minor diameter of ring thread gages.

S. S. Depth. Sharp Single Depth of theoretical "V" thread deducted from major diameter will give theoretical "V" pitch diameter.

Mod. S. Depth. Single Depth of modified "V" or amount to deduct from major diameter to obtain pitch diameter of modified "V". Used by most tap makers to obtain pitch diameter of "V" thread taps. Modified "V" depth = .75 × Pitch.

National Form of Thread					"V" Thread	
T. P. I.	Pitch	S. Depth	D. Depth	83⅓% D. Depth	S. S. Depth	Mod. S. Depth
2	.500000	.324759	.649519	.541265	.433015	.375000
2½	.444444	.288675	.577350	.481125	.384898	.333333
2⅝	.421052	.273481	.546962	.455801	.364643	.315789
2⅞	.400000	.259807	.519614	.433012	.346412	.300000
3	.380952	.247435	.494870	.412392	.329915	.285714
3⅛	.363636	.236188	.472376	.393647	.314919	.272727
3½	.347826	.225920	.451480	.376533	.301230	.260871
4	.333333	.216506	.433012	.360843	.288675	.249999
4½	.307692	.199852	.399704	.333086	.266469	.230769
5	.285711	.185577	.371154	.309294	.247432	.214283
5½	.250000	.162379	.324758	.270631	.216506	.187500
6	.222222	.144337	.288674	.240561	.192450	.166666
7	.200000	.129903	.259806	.216504	.173205	.150000
8	.181818	.118093	.236186	.196821	.157459	.136363
9	.166666	.108253	.216506	.180421	.144337	.125000
10	.142857	.092788	.185576	.154646	.123717	.107142
11	.125000	.081189	.162378	.135314	.108253	.093750
12	.111111	.072168	.144336	.120279	.096225	.083333
13	.100000	.064952	.129904	.108253	.086602	.075000
14	.090909	.059046	.118092	.098409	.078729	.068181
15	.083333	.054127	.108255	.090212	.072168	.062500
16	.076923	.049963	.099926	.083271	.066617	.057692
17	.071428	.046394	.092788	.077323	.061858	.053571
18	.062500	.040595	.081190	.067658	.054126	.046875
19	.055555	.036086	.072172	.060143	.048112	.041666
20	.052631	.034185	.068370	.056974	.045580	.039473
22	.050000	.032475	.064950	.054124	.043301	.037500
24	.045454	.029523	.059046	.049204	.039364	.034090
26	.041666	.027063	.054126	.045104	.036084	.031249
28	.037037	.024056	.048112	.040093	.032075	.027777
30	.035714	.023197	.046394	.038661	.030929	.026785
32	.033333	.021651	.043302	.036084	.028867	.025000
34	.031250	.020297	.040594	.033828	.027063	.023437
36	.029411	.019103	.038206	.031838	.025471	.022058
38	.027777	.018042	.036084	.030069	.024057	.020833
40	.025000	.016237	.032474	.027061	.021650	.018750
44	.022727	.014761	.029522	.024603	.019682	.017045
48	.020833	.013531	.027062	.022551	.018042	.015824
50	.020000	.012990	.025980	.021649	.017320	.015000
56	.017857	.011598	.023196	.019329	.015465	.013392
64	.015625	.010148	.020296	.016913	.013531	.011718
72	.013888	.009021	.018042	.015034	.012028	.010416
80	.012500	.008118	.016236	.013529	.010825	.009375

★ "GREENFIELD" TOOLS ★

Pitch Diameter Gaging Limits

For Classes 1, 2, 3 & 4 Fits

National Screw Thread Commission Standard

Machine Screw and Fractional Sizes

NOTE:—Limits shown in each column represent "Go" and "Not Go" sizes.

SCREWS (RING THREAD GAGES)					NUTS (PLUG THREAD GAGES)				
Size	Loose Fit Class 1	Free Fit Class 2	Medium Fit Class 3	Close Fit Class 4	Basic P. D.	Loose Fit Class 1	Free Fit Class 2	Medium Fit Class 3	Close Fit Class 4
0-80	.0512 .0488	.0519 .0502	.0519 .0506	........	.0519	.0543 .0519	.0536 .0519	.0532 .0519	........
1-72	.0633 .0608	.0640 .0622	.0640 .0627	........	.0640	.0665 .0640	.0658 .0640	.0653 .0640	........
1-64	.0622 .0596	.0629 .0610	.0629 .0615	........	.0629	.0655 .0629	.0648 .0629	.0643 .0629	........
2-64	.0752 .0726	.0759 .0740	.0759 .0745	........	.0759	.0785 .0759	.0778 .0759	.0773 .0759	........
2-56	.0736 .0708	.0744 .0724	.0744 .0729	........	.0744	.0772 .0744	.0764 .0744	.0759 .0744	........
3-56	.0866 .0838	.0874 .0854	.0874 .0859	........	.0874	.0902 .0874	.0894 .0874	.0889 .0874	........
3-48	.0846 .0815	.0855 .0833	.0855 .0839	........	.0855	.0886 .0855	.0877 .0855	.0871 .0855	........
4-48	.0976 .0945	.0985 .0963	.0985 .0969	........	.0985	.1016 .0985	.1007 .0985	.1001 .0985	........
4-40	.0948 .0914	.0958 .0934	.0958 .0941	........	.0958	.0992 .0958	.0982 .0958	.0975 .0958	........
5-44	.1093 .1061	.1102 .1079	.1102 .1086	........	.1102	.1134 .1102	.1125 .1102	.1118 .1102	........
5-40	.1078 .1044	.1088 .1064	.1088 .1071	........	.1088	.1122 .1088	.1112 .1088	.1105 .1088	........
6-40	.1208 .1174	.1218 .1194	.1218 .1201	........	.1218	.1252 .1218	.1242 .1218	.1235 .1218	........
6-32	.1166 .1128	.1177 .1150	.1177 .1158	........	.1177	.1215 .1177	.1204 .1177	.1196 .1177	........
8-36	.1449 .1413	.1460 .1435	.1460 .1442	........	.1460	.1496 .1460	.1485 .1460	.1478 .1460	........
8-32	.1426 .1388	.1437 .1410	.1437 .1418	........	.1437	.1475 .1437	.1464 .1437	.1456 .1437	........
10-32	.1686 .1648	.1697 .1670	.1697 .1678	........	.1697	.1735 .1697	.1724 .1697	.1716 .1697	........
10-24	.1616 .1570	.1629 .1596	.1629 .1605	........	.1629	.1675 .1629	.1662 .1629	.1653 .1629	........
12-28	.1916 .1873	.1928 .1897	.1928 .1906	........	.1928	.1971 .1928	.1959 .1928	.1950 .1928	........
12-24	.1876 .1830	.1889 .1856	.1889 .1865	........	.1889	.1935 .1889	.1922 .1889	.1913 .1889	........
¼-28	.2256 .2213	.2268 .2237	.2268 .2246	.2270 .2259	.2268	.2311 .2268	.2299 .2268	.2290 .2268	.2279 .2268
¼-20	.2160 .2109	.2175 .2139	.2175 .2149	.2178 .2165	.2175	.2226 .2175	.2211 .2175	.2201 .2175	.2188 .2175
⅝-24	.2841 .2795	.2854 .2821	.2854 .2830	.2857 .2845	.2854	.2900 .2854	.2887 .2854	.2878 .2854	.2866 .2854
⅝-18	.2748 .2691	.2764 .2723	.2764 .2734	.2767 .2752	.2764	.2821 .2764	.2805 .2764	.2794 .2764	.2779 .2764

"GREENFIELD" TOOLS

Pitch Diameter Gaging Limits

For Classes 1, 2, 3 & 4 Fits

National Screw Thread Commission Standard

Fractional Sizes

NOTE:—Limits shown in each column represent "Go" and "Not Go" gage sizes.

SCREWS (RING THREAD GAGES)					NUTS (PLUG THREAD GAGES)				
Size	Loose Fit Class 1	Free Fit Class 2	Medium Fit Class 3	Close Fit Class 4	Basic P. D.	Loose Fit Class 1	Free Fit Class 2	Medium Fit Class 3	Close Fit Class 4
$\frac{3}{8}$ -24	.3466 .3420	.3479 .3446	.3479 .3455	.3482 .3470	.3479	.3525 .3479	.3512 .3479	.3503 .3479	.3491 .3479
$\frac{3}{8}$ -16	.3326 .3263	.3344 .3299	.3344 .3312	.3348 .3332	.3344	.3407 .3344	.3389 .3344	.3376 .3344	.3360 .3344
$\frac{7}{16}$ -20	.4035 .3984	.4050 .4014	.4050 .4024	.4053 .4040	.4050	.4101 .4050	.4086 .4050	.4076 .4050	.4063 .4050
$\frac{7}{16}$ -14	.3890 .3820	.3911 .3862	.3911 .3875	.3915 .3897	.3911	.3981 .3911	.3960 .3911	.3947 .3911	.3929 .3911
$\frac{1}{2}$ -20	.4660 .4609	.4675 .4639	.4675 .4649	.4678 .4665	.4675	.4726 .4675	.4711 .4675	.4701 .4675	.4688 .4675
$\frac{1}{2}$ -13	.4478 .4404	.4500 .4448	.4500 .4463	.4504 .4485	.4500	.4574 .4500	.4552 .4500	.4537 .4500	.4519 .4500
$\frac{9}{16}$ -18	.5248 .5191	.5264 .5223	.5264 .5234	.5267 .5252	.5264	.5321 .5264	.5305 .5264	.5294 .5264	.5279 .5264
$\frac{9}{16}$ -12	.5060 .4981	.5084 .5028	.5084 .5044	.5089 .5069	.5084	.5163 .5084	.5140 .5084	.5124 .5084	.5104 .5084
$\frac{5}{8}$ -18	.5873 .5816	.5889 .5848	.5889 .5859	.5892 .5877	.5889	.5946 .5889	.5930 .5889	.5919 .5889	.5904 .5889
$\frac{5}{8}$ -11	.5634 .5549	.5660 .5601	.5660 .5618	.5665 .5644	.5660	.5745 .5660	.5719 .5660	.5702 .5660	.5681 .5660
$\frac{3}{4}$ -16	.7076 .7013	.7094 .7049	.7094 .7062	.7098 .7082	.7094	.7157 .7094	.7139 .7094	.7126 .7094	.7110 .7094
$\frac{3}{4}$ -10	.6822 .6730	.6850 .6786	.6850 .6805	.6856 .6833	.6850	.6942 .6850	.6914 .6850	.6895 .6850	.6873 .6850
$\frac{7}{8}$ -14	.8265 .8195	.8286 .8237	.8286 .8250	.8290 .8272	.8286	.8356 .8286	.8335 .8286	.8322 .8286	.8304 .8286
$\frac{7}{8}$ -9	.7997 .7897	.8028 .7958	.8028 .7979	.8034 .8010	.8028	.8128 .8028	.8098 .8028	.8077 .8028	.8052 .8028
1 -14	.9515 .9445	.9536 .9487	.9536 .9500	.9540 .9522	.9536	.9606 .9536	.9585 .9536	.9572 .9536	.9554 .9536
1 -8	.9154 .9043	.9188 .9112	.9188 .9134	.9195 .9168	.9188	.9299 .9188	.9264 .9188	.9242 .9188	.9215 .9188
$1\frac{1}{8}$ -12	1.0685 1.0606	1.0709 1.0653	1.0709 1.0669	1.0714 1.0694	1.0709	1.0788 1.0709	1.0765 1.0709	1.0749 1.0709	1.0729 1.0709
$1\frac{1}{8}$ -7	1.0283 1.0159	1.0322 1.0237	1.0322 1.0263	1.0330 1.0300	1.0322	1.0446 1.0322	1.0407 1.0322	1.0381 1.0322	1.0352 1.0322
$1\frac{1}{4}$ -12	1.1935 1.1856	1.1959 1.1903	1.1959 1.1919	1.1964 1.1944	1.1959	1.2038 1.1959	1.2015 1.1959	1.1999 1.1959	1.1979 1.1959
$1\frac{1}{4}$ -7	1.1533 1.1409	1.1572 1.1487	1.1572 1.1513	1.1580 1.1550	1.1572	1.1696 1.1572	1.1657 1.1572	1.1631 1.1572	1.1602 1.1572
$1\frac{1}{2}$ -12	1.4435 1.4356	1.4459 1.4403	1.4459 1.4419	1.4464 1.4444	1.4459	1.4538 1.4459	1.4515 1.4459	1.4499 1.4459	1.4479 1.4459
$1\frac{1}{2}$ -6	1.3873 1.3728	1.3917 1.3816	1.3917 1.3846	1.3926 1.3890	1.3917	1.4062 1.3917	1.4018 1.3917	1.3988 1.3917	1.3953 1.3917

★ "GREENFIELD" TOOLS ★

Table of Cutting Speeds

Feet per Min.	30'	40'	50'	60'	70'	80'	90'	100'	110'	120'	130'	140'	150'
Diameter Inches	Revolutions per Minute												
$\frac{1}{16}$	1833	2445	3056	3667	4278	4889	5500	6111	6722	7334	7945	8556	9167
$\frac{3}{16}$	917	1222	1528	1833	2139	2445	2750	3056	3361	3667	3973	4278	4584
$\frac{1}{8}$	611	815	1019	1222	1426	1630	1833	2037	2241	2445	2648	2852	3056
$\frac{3}{8}$	458	611	764	917	1070	1222	1375	1528	1681	1833	1986	2139	2292
$\frac{5}{16}$	367	489	611	733	856	978	1100	1222	1345	1467	1589	1711	1833
$\frac{3}{8}$	306	407	509	611	713	815	917	1019	1120	1222	1324	1426	1528
$\frac{1}{2}$	262	349	437	524	611	698	786	873	960	1048	1135	1222	1310
$\frac{3}{4}$	229	306	382	458	535	611	688	764	840	917	993	1070	1146
$\frac{5}{8}$	183	244	306	367	428	489	550	611	672	733	794	856	917
$\frac{3}{4}$	153	203	255	306	357	407	458	509	560	611	662	713	764
$\frac{7}{8}$	131	175	218	262	306	349	393	436	480	524	568	611	655
1	115	153	191	229	267	306	344	382	420	458	497	535	573
$1\frac{1}{8}$	102	136	170	204	238	272	306	340	373	407	441	475	509
$1\frac{1}{4}$	92	122	153	183	214	244	275	306	336	367	397	428	458
$1\frac{3}{8}$	83	111	139	167	194	222	250	278	306	333	361	389	417
$1\frac{1}{2}$	76	102	127	153	178	204	229	255	280	306	331	357	382
$1\frac{3}{4}$	70	94	117	141	165	188	212	235	259	282	306	329	353
$1\frac{7}{8}$	65	87	109	131	153	175	196	218	240	262	284	306	327
$1\frac{7}{8}$	61	81	102	122	143	163	183	204	224	244	265	285	306
2	57	76	95	115	134	153	172	191	210	229	248	267	287
$2\frac{1}{4}$	51	68	85	102	119	136	153	170	187	204	221	238	255
$2\frac{1}{2}$	46	61	76	92	107	122	137	153	168	183	199	214	229
$2\frac{3}{4}$	42	56	69	83	97	111	125	139	153	167	181	194	208
3	38	51	64	76	89	102	115	127	140	153	166	178	191

★ "GREENFIELD" TOOLS ★

Table of Decimal Equivalents

Decimal Equivalent	Fractional Inch	Machine Screw Standard	Wire	British Association Tap Standard	Millimeter
.00391
.00792
.01183
.0135	80	.....	.....
.0145	79	.....	.....
.0156	$\frac{1}{64}$	.....	.....	.....	.4
.0157
.0160	78	.....	.....
.0180	77	.....	.....
.01975
.0200	76	.....	.....
.0210	75	.....	.....
.0225	74	.....	.....
.02366
.0240	73	.....	.....
.0250	72	.....	.....
.0260	71	.....	.....
.02767
.0280	70	.....	.....
.0292	69	.....	.....
.0310	68	.....	.....
.0312	$\frac{1}{32}$	.....	.....	.....	.....
.03158
.0320	67	.....	.....
.0330	66	.....	.....
.0350	65	.....	.....
.03549
.0360	64	.....	.....
.0370	63	.....	.....
.0380	62	.....	.....
.0390	61	.....	.....
.0394	1.
.0400	60	.....	.....
.0410	59	.....	.....
.0420	58	.....	.....
.0430	57	.....	.....
.0433	1.1
.0465	56	.....	.....
.0469	$\frac{3}{64}$	.....	.....	.....	.....
.0472	1.2
.0492	1.25
.0512	1.3
.051	12	.....
.0520	55	.....	.....
.0550	54	.....	.....
.0551	1.4
.0590	11	1.5
.0595	53	.....	.....
.060	0	.....	.....	.....
.0625	$\frac{1}{16}$	.....	.....	.....	.....
.0630	1.6

★ "GREENFIELD" TOOLS ★

Table of Decimal Equivalents (Continued)

Decimal Equivalent	Fractional Inch	Machine Screw Standard	Wire	British Association Tap Standard	Millimeter
.0635	52	.....	.....
.0669	1.7
.0670	51	10	.....
.0689	1.75
.0700	50	.....	.....
.0709	1.8
.0730	1	49	.....	.....
.0748	1.9
.075	9	.....
.0760	48	.....	.....
.0781	$\frac{1}{4}$	.....	.....	.....	.....
.0785	47	.....	.....
.0787	2.
.0810	46	.....	.....
.0820	45	.....	.....
.0827	2.1
.0860	2	44	.....	.....
.0866	2.2
.087	8	.....
.0886	2.25
.0890	43	.....	.....
.0905	2.3
.0935	42	.....	.....
.0937	$\frac{1}{4}$	.....	.....	.....	.....
.0945	2.4
.0960	41	.....	.....
.0980	40	7	.....
.0984	2.5
.099	3	.....	.....	.....
.0995	39	.....	.....
.1015	38	.....	.....
.1024	2.6
.1040	37	.....	.....
.1063	2.7
.1065	36	.....	.....
.1083	2.75
.1094	$\frac{1}{4}$	.....	.....	.....	.....
.1100	35	6	.....
.1102	2.8
.1110	34	.....	.....
.112	4	.....	.....	.....
.1130	33	.....	.....
.1142	2.9
.1160	32	.....	.....
.1181	3.
.1200	31	.....	.....
.1220	3.1
.1250	$\frac{1}{2}$	5	.....	.....	.....
.1260	5	.....
.1280	3.2
.1285	30	.....	3.25

★ "GREENFIELD" TOOLS ★

Table of Decimal Equivalents (Continued)

Decimal Equivalent	Fractional Inch	Machine Screw Standard	Wire	British Association Tap Standard	Millimeter
.1299					3.3
.1339					3.4
.1360			29		
.1378					3.5
.138		6			
.1405			28		
.1406	$\frac{9}{64}$				
.1417					3.6
.142				4	
.1440			27		
.1457					3.7
.1470			26		
.1476					3.75
.1495			25		
.1496					3.8
.151		7			
.1520			24		
.1535					3.9
.1540			23		
.1562	$\frac{5}{32}$				
.1570			22		
.1575					4.
.1590			21		
.1610			20	3	
.1614					4.1
.164		8			
.1654					4.2
.1660			19		
.1673					4.25
.1693					4.3
.1695			18		
.1719	$\frac{11}{64}$				
.1730			17		
.1732					4.4
.1770		9	16		
.1772					4.5
.1800			15		
.1811					4.6
.1820			14		
.1850			13	2	
.1870					4.75
.1875	$\frac{3}{16}$				
.1890			12		4.8
.190		10			
.1910			11		
.1929					4.9
.1935			10		
.1960			9		
.1968					5.
.1990			8		
.2008					5.1

★ "GREENFIELD" TOOLS ★

Table of Decimal Equivalents (Continued)

Decimal Equivalent	Fractional Inch	Machine Screw Standard	Wire	British Association Tap Standard	Millimeter
.2010	7	.....	.....
.2031	$\frac{13}{64}$	.....	6	.....	.....
.2040	6	.....	.....
.2047	5.2
.2055	5	.....	.....
.2067	5.25
.2087	5.3
.2090	4	1	.....
.2126	5.4
.2130	3	.....	.....
.216	12	.....	.....	.....
.2165	5.5
.2187	$\frac{7}{32}$	.....	.....	.....	.....
.2205	2	.....	5.6
.2210	2	.....	.....
.2244	5.7
.2264	5.75
.2280	1	.....	.....
.2283	5.8
.2323	Letter	.....	5.9
.2340	A	.....	.....
.2344	$\frac{13}{64}$	.....	.....	.....	.....
.236	0	.....
.2362	6.
.2380	B	.....	.....
.2402	6.1
.2420	14	C	.....	.....
.2441	6.2
.2460	D	.....	.....
.2461	6.25
.2480	6.3
.2500	$\frac{1}{4}$	.....	E	.....	.....
.2520	6.4
.2559	6.5
.2570	F	.....	.....
.2598	6.6
.2610	G	.....	.....
.2638	6.7
.2656	$\frac{17}{64}$	.....	.....	.....	.....
.2657	6.75
.2660	H	.....	.....
.2677	6.8
.268	16	.....	.....	.....
.2717	6.9
.2720	I	.....	.....
.2756	7.
.2770	J	.....	.....
.2795	7.1
.2810	K	.....	.....
.2812	$\frac{9}{32}$	.....	.....	.....	.....



Table of Decimal Equivalents
(Continued)

Decimal Equivalent	Fractional Inch	Machine Screw Standard	Letter	British Association Tap Standard	Millimeter
.2835	7.2
.2854	7.25
.2874	7.3
.2900	L	.....	.....
.2913	7.4
.294	18	.....	.....	.....
.2950	M	.....	.....
.2953	7.5
.2969	$\frac{19}{64}$	.....	.....	.....	.....
.2992	7.6
.3020	N	.....	.....
.3031	7.7
.3051	7.75
.3071	7.8
.3110	7.9
.3125	$\frac{5}{16}$	.....	.....	.....	.....
.3150	8.
.3160	O	.....	.....
.3189	8.1
.320	20	.....	.....	.....
.3228	8.2
.3230	P	.....	.....
.3248	8.25
.3268	8.3
.3281	$\frac{21}{64}$	.....	.....	.....	.....
.3307	8.4
.3320	Q	.....	.....
.3346	8.5
.3386	8.6
.3390	R	.....	.....
.3425	8.7
.3437	$\frac{11}{32}$	.....	.....	.....	.....
.3445	8.75
.346	22	.....	.....	.....
.3465	8.8
.3480	S	.....	.....
.3504	8.9
.3543	9.
.3580	T	.....	.....
.3583	9.1
.3594	$\frac{23}{64}$	.....	.....	.....	.....
.3622	9.2
.3642	9.25
.3661	9.3
.3680	U	.....	.....
.3701	9.4
.372	24	.....	.....	.....
.3740	9.5
.3750	$\frac{3}{8}$	.....	.....	.....	.....
.3770	V	.....	.....
.3780	9.6

★ "GREENFIELD" TOOLS ★

Table of Decimal Equivalents (Continued)

Decimal Equivalent	Fractional Inch	Machine Screw Standard	Letter	British Association Tap Standard	Millimeter
.3819	.....	.....	.....	.....	9.7
.3839	.....	.....	.....	.....	9.75
.3858	.....	.....	.....	.....	9.8
.3860	.....	.....	W	.....	.....
.3898	.....	.....	.....	.....	9.9
.3906	$\frac{25}{64}$	.....	.....	.....	.....
.3937	.....	.....	.....	.....	10.
.3970	.....	26	X	.....	.....
.398	.....	.....	.....	.....	10.25
.4035	.....	.....	.....	.....	.....
.4040	.....	.....	Y	.....	.....
.4062	$\frac{13}{32}$	.....	.....	.....	.....
.4130	.....	.....	Z	.....	.....
.4134	.....	.....	.....	.....	10.5
.4219	$\frac{27}{64}$	.....	.....	.....	.....
.4232	.....	.....	.....	.....	10.75
.424	.....	28	.....	.....	.....
.4331	.....	.....	.....	.....	11.
.4375	$\frac{7}{16}$	.....	.....	.....	.....
.4429	.....	.....	.....	.....	11.25
.450	.....	30	.....	.....	.....
.4528	.....	.....	.....	.....	11.5
.4531	$\frac{29}{64}$	.....	.....	.....	.....
.4626	.....	.....	.....	.....	11.75
.4687	$\frac{15}{32}$	.....	.....	.....	.....
.4724	.....	.....	.....	.....	12.
.4823	.....	.....	.....	.....	12.25
.4844	$\frac{31}{64}$	.....	.....	.....	.....
.4921	.....	.....	.....	.....	12.5
.5000	$\frac{1}{2}$	.....	.....	.....	.....
.5020	.....	.....	.....	.....	12.75
.5118	.....	.....	.....	.....	13.
.5156	$\frac{33}{64}$	.....	.....	.....	.....
.5312	$\frac{17}{32}$	.....	.....	.....	.....
.5315	.....	.....	.....	.....	13.5
.5469	$\frac{35}{64}$	.....	.....	.....	.....
.5512	.....	.....	.....	.....	14.
.5625	$\frac{9}{16}$	.....	.....	.....	.....
.5709	.....	.....	.....	.....	14.5
.5781	$\frac{37}{64}$	.....	.....	.....	.....
.5906	.....	.....	.....	.....	15.
.5937	$\frac{19}{32}$	.....	.....	.....	.....
.6094	$\frac{39}{64}$	.....	.....	.....	.....
.6102	.....	.....	.....	.....	15.5
.6250	$\frac{5}{8}$	.....	.....	.....	.....
.6299	.....	.....	.....	.....	16.
.6406	$\frac{41}{64}$	.....	.....	.....	.....
.6496	.....	.....	.....	.....	16.5

★ "GREENFIELD" TOOLS ★

Table of Decimal Equivalents

(Continued)

Decimal Equivalent	Fractional Inch	Millimeter	Decimal Equivalent	Fractional Inch	Millimeter
.6562	$\frac{21}{32}$	.....	1.0000	1	.....
.6693	.....	17.	1.0039	.....	25.5
.6719	$\frac{43}{64}$	.....	1.0156	$1 \frac{1}{64}$	.....
.6875	$\frac{11}{16}$	.....	1.0236	.....	26.
.6890	.....	17.5	1.0312	$1 \frac{1}{32}$	.....
.7031	$\frac{45}{64}$	.....	1.0433	.....	26.5
.7087	.....	18.	1.0469	$1 \frac{3}{64}$	.....
.7187	$\frac{23}{32}$	.....	1.0625	$1 \frac{1}{16}$	.....
.7283	.....	18.5	1.0630	.....	27.
.7344	$\frac{47}{64}$	.....	1.0781	$1 \frac{5}{64}$	.....
.7480	.....	19.	1.0827	.....	27.5
.7500	$\frac{3}{4}$	.....	1.0937	$1 \frac{3}{32}$	.....
.7656	$\frac{49}{64}$	.....	1.1024	.....	28.
.7677	.....	19.5	1.1094	$1 \frac{7}{64}$	.....
.7812	$\frac{25}{32}$	.....	1.1220	.....	28.5
.7874	.....	20.	1.1250	$1 \frac{1}{8}$	.....
.7969	$\frac{51}{64}$	.....	1.1406	$1 \frac{9}{64}$	.....
.8071	.....	20.5	1.1417	.....	29.
.8125	$\frac{13}{16}$	.....	1.1562	$1 \frac{5}{32}$	.....
.8268	.....	21.	1.1614	.....	29.5
.8281	$\frac{53}{64}$	.....	1.1719	$1 \frac{11}{64}$	.....
.8437	$\frac{57}{64}$	.....	1.1811	.....	30.
.8465	.....	21.5	1.1875	$1 \frac{3}{16}$	.....
.8594	$\frac{55}{64}$	.....	1.2008	.....	30.5
.8661	.....	22.	1.2031	$1 \frac{13}{64}$	.....
.8750	$\frac{7}{8}$	.....	1.2187	$1 \frac{7}{32}$	.....
.8858	.....	22.5	1.2205	.....	31.
.8906	$\frac{57}{64}$	.....	1.2344	$1 \frac{15}{64}$	.....
.9055	.....	23.	1.2402	.....	31.5
.9062	$\frac{29}{32}$	.....	1.2500	$1 \frac{1}{4}$	.....
.9219	$\frac{59}{64}$	.....	1.2598	.....	32.
.9252	.....	23.5	1.2656	$1 \frac{17}{64}$	.....
.9375	$\frac{15}{16}$	.....	1.2795	.....	32.5
.9449	.....	24.	1.2812	$1 \frac{9}{32}$	.....
.9531	$\frac{61}{64}$	.....	1.2969	$1 \frac{19}{64}$	.....
.9646	.....	24.5	1.2992	.....	33.
.9687	$\frac{31}{32}$	.....	1.3125	$1 \frac{5}{16}$	.....
.9842	.....	25.	1.3189	.....	33.5
.9844	$\frac{63}{64}$	.....	1.3281	$1 \frac{21}{64}$	.....



Table of Decimal Equivalents
(Concluded)

Decimal Equivalent	Fractional Inch	Millimeter	Decimal Equivalent	Fractional Inch	Millimeter
1.3386	.....	34.	1.6732	.....	42.5
1.3437	$1\frac{11}{32}$	.....	1.6875	$1\frac{11}{16}$	.....
1.3583	.....	34.5	1.6929	.....	43.
1.3594	$1\frac{23}{64}$	.....	1.7031	$1\frac{45}{64}$	.....
1.3750	$1\frac{3}{8}$	.....	1.7126	.....	43.5
1.3779	.....	35.	1.7187	$1\frac{23}{32}$	.....
1.3906	$1\frac{25}{64}$	.....	1.7323	.....	44.
1.3976	.....	35.5	1.7344	$1\frac{47}{64}$	.....
1.4062	$1\frac{13}{32}$	.....	1.7500	$1\frac{3}{4}$	.....
1.4173	.....	36.	1.7520	.....	44.5
1.4219	$1\frac{27}{64}$	.....	1.7656	$1\frac{49}{64}$	.....
1.4370	.....	36.5	1.7716	.....	45.
1.4375	$1\frac{7}{16}$	.....	1.7812	$1\frac{25}{32}$	.....
1.4531	$1\frac{29}{64}$	.....	1.7913	.....	45.5
1.4567	.....	37.	1.7969	$1\frac{51}{64}$	.....
1.4687	$1\frac{15}{32}$	.....	1.8110	.....	46.
1.4764	.....	37.5	1.8125	$1\frac{13}{16}$	.....
1.4844	$1\frac{31}{64}$	.....	1.8281	$1\frac{53}{64}$	.....
1.4961	.....	38.	1.8307	.....	46.5
1.5000	$1\frac{1}{2}$	.....	1.8437	$1\frac{27}{32}$	.....
1.5156	$1\frac{33}{64}$	.....	1.8504	.....	47.
1.5157	.....	38.5	1.8594	$1\frac{55}{64}$	.....
1.5312	$1\frac{17}{32}$	.....	1.8701	.....	47.5
1.5354	.....	39.	1.8750	$1\frac{7}{8}$	.....
1.5469	$1\frac{35}{64}$	.....	1.8898	.....	48.
1.5551	.....	39.5	1.8906	$1\frac{57}{64}$	.....
1.5625	$1\frac{9}{16}$	.....	1.9062	$1\frac{29}{32}$	.....
1.5748	.....	40.	1.9094	.....	48.5
1.5781	$1\frac{37}{64}$	.....	1.9219	$1\frac{59}{64}$	.....
1.5937	$1\frac{19}{32}$	.....	1.9291	.....	49.
1.5945	.....	40.5	1.9375	$1\frac{15}{16}$	.....
1.6094	$1\frac{39}{64}$	.....	1.9488	.....	49.5
1.6142	.....	41.	1.9531	$1\frac{61}{64}$	.....
1.6250	$1\frac{5}{8}$	.....	1.9685	.....	50.
1.6339	.....	41.5	1.9687	$1\frac{31}{32}$	.....
1.6406	$1\frac{41}{64}$	1.9844	$1\frac{63}{64}$
1.6535	42.	1.9882	50.5
1.6562	$1\frac{21}{32}$	2.0000	2
1.6719	$1\frac{43}{64}$	2.0079	51.

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